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THIS IS THE SECOND PAPER RELEASED BY THE TECHNOLOGICAL DEVELOPMENT PROJECT DEALING WITH THE HISTORICAL BACKGROUND OF THE DEVELOPING INSTRUCTIONAL TECHNOLOGY IN AMERICAN EDUCATION. THE BASIS OF THE WORK PRESENTED HERE WAS THE L. PAUL SAETTLER'S DISSERTATION, "THE ORIGIN AND DEVELOPMENT OF AUDIOVISUAL COMMUNICATION IN EDUCATION" (UNIVERSITY OF SOUTHERN CALIFORNIA, 1953). THE FOLLOWING TECHNOLOGIES ARE TRACED--PICTORIAL AND GRAPHIC ARTS, PROJECTED STILL PICTURES, MOTION PICTURES, AUDITORY MEDIA, FACSIMILE, TELEVISION, AND TEACHING MACHINES. ACCOMPANYING ILLUSTRATIONS APPEAR IN THE LAST SECTION OF THE REPORT. (JC)

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Occasional Paper No. 2

HISTORY OF INSTRUCTIONAL TECHNOLOGY, II: THE TECHNICAL DEVELOPMENT OF THE NEW MEDIA

by

L. Paul Saettler

A Report Prepared for the
TECHNOLOGICAL DEVELOPMENT PROJECT
of the
NATIONAL EDUCATION ASSOCIATION OF THE UNITED STATES*

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*This report consists primarily of the body of a chapter from Dr. Saettler's forthcoming book, History of Audio-Visual Communication, to be published by Wm. C. Brown Co., Spring 1962. Permission has been granted to publish this material for purposes of the Technological Development Project. Dr. Saettler is Assistant Professor of Education, Sacramento State College.

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Publication Note

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FOREWORD

This is the second study released by the Technological Development Project dealing with the historical background of the developing instructional technology in American education. We were fortunate to be able to use the work of Dr. L. Paul Saettler, a member of the faculty of Sacramento State College.

The basis of the work presented here was created some years ago in Dr. Saettler's dissertation, The Origin and Development of Audio-Visual Communication in Education (University of Southern California, 1953). This monumental, three volume work covered the entire sweep of the development of audio-visual means of communication from cave-paintings to the present.

Dr. Saettler has kept up his interest in the field of audio-visual history and, over the years, has revised and added to his materials. He has now written a book which is soon to be published. In reviewing the manuscript of the book, we found that one chapter contained a great deal of material pertinent to the background information we were gathering for the study. We asked Dr. Saettler if he would give us permission to use this material and if so, to make certain additions that had direct application to the needs of the Technological Development Project. This he agreed to do, and the result is this project paper.

Again, no claim is made that the material presented here is all derived from first-hand sources. The sweep of the effort, embracing the technologies of photography, sound, electronics, etc., is obviously too great to permit such an approach in what was, after all, only an introductory portion of a larger work. However, the effect achieved--a picture of the complex technical base upon which modern communication devices are constructed--is completely appropriate to the method.

In other parts of his work, Saettler has handled much first-hand material, including interviews with pioneers of the audio-visual movement that are now deceased. The reader who is interested is referred to the forthcoming book.

Grateful acknowledgment is also made to Mr. Lee Cochran of Iowa State University who supplied the illustrations appearing in the last section. Lee Cochran has for years worked with the Archives and History Committee of the Department of Audio Visual Instruction, NEA in developing the DAVI Archives Collection at the State University of Iowa. Whenever called upon Lee Cochran has given generously of his time in locating hard to get materials. He has been most helpful in the preparation of this paper.

Again, in passing, the reader is reminded that, since it is the job of the Technological Development Project to assess the future of technology in American education, history, one of the few possible guidelines to the future, is one source to which we must continually turn.

James D. Finn
Los Angeles
July, 1961

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TECHNOLOGY AND AUDIO-VISUAL COMMUNICATION

Technology has had an impressive influence upon industry and transportation, but there is no more striking example of the effect of technology than that found in the realm of communication. The field of communication, which can be defined as the transmission of meanings through the use of symbols, has had a tremendous development over the centuries.

Beginning with the simplest forms of communication--the spoken or written word, gesture, grimace, intonation of voice--technology has added the telephone, telegraph, loud speaker, the printing press, photography, the motion picture, radio, television, and the electronic machine. Without these technological innovations in communications, the audio-visual communication movement as we know it could not have developed.

Impact of Communications Revolution. Nothing has affected the philosophy of man, the texture and variety of our culture, or our attitudes and behavior more than the changes made in communications. Face-to-face communications and pictorial symbols were the first kinds of human communication to develop. Modern communication can be dated from about the year 1450 when in Mainz, Germany, the printing press duplicated inter-personal communication and began to disseminate messages to large masses of people. But it was a long period after 1450 before the telegraph, the camera and photoengraving enabled man to interpose in the communication process so that machines could see and listen for him.

The third phase of the communication revolution developed when a communication system between man and man through machines became possible. This development came in the latter part of the nineteenth century with the invention of the telephone. A few years later Edison's phonograph and motion picture camera, the motion picture projector, DeForest's triode vacuum tube (making the development of radio and television possible), and radar brought the third phase of the communications revolution to its fruition.

The startling contrast between communication before and after 1876 was that man had begun to develop machines which would be interposed in the communication network and be relied upon to listen and see for him. The printing machine had also been interposed in the communication process, but it could only duplicate, it could not communicate directly.

The fourth phase of the communication revolution was the development of machine-to-machine communication. This stage is still relatively new and has only really blossomed forth in the last decade. For the first time, man is able to feed and store information into machines and have them react and automatically respond at set times in the performance of a specific task. Thus it has become possible to have automatic fixtures and devices that remember facts and make decisions.

Pictorial and Graphic Arts

One of the vital threads in the technological warp of audio-visual communication has been the invention of photography and its various offshoots. The greatest mystery in its history is why it was not invented before the nineteenth century. Knowledge of both optical and chemical principles on which it is based was well known in the eighteenth century.

The Pre-History of Photography. The photographic camera derives directly from the camera obscura. The camera, at first a dark room big enough for a man to enter, gradually grew smaller. It had a tiny hole in the wall or window-shutter through which the view outside was projected, upside-down, on to the opposite wall or a white screen.

The principles of the camera obscura were described by Alhazen (?965-?1039), who proposed it for observing solar eclipses, and for over five centuries its use remained confined to this purpose. The principles of the camera obscura were also well known to such men as Aristotle, Euclid, Leonardo da Vinci, Kepler, and Robert Boyle. The first practical step toward the development of the camera obscura seems to have been made by the famour painter and architect, Leon Battista Alberti, in 1437, contemporaneously with the invention of printing. The first published account of the camera obscura was given by Cesare Caesariano in 1521. Giovanni Battista della Porta's book Magio Naturalis (1553) gave a similar account. Some fifteen years later, Danielo Barbaro showed that a more brilliant image could be produced by substituting an ordinary convex lens for a pinhole. In the seventeenth and eighteenth centuries, a lens was fitted into one end of a two-foot box, and the other end covered with a sheet of frosted or ground glass. The image cast on the ground glass by the lens could be seen outside the camera. This offered a valuable mechanical aid to artists in solving their perspective problems. The images of nature could now be reflected. It only remained for man to trap the illusive image of the camera by his invention of photography.

Photography. The invention of photography cannot be attributed to any one man. Rather, it has resulted from the observations and experiments of early alchemists and chemists on the action of light. Although the gradual blackening of silver and its compounds was known to the ancient Egyptians, it was not until the sixteenth century when Georgius Fabricius first recorded that silver chloride or "horn silver' would darken when exposed to light. In 1727, Johann Heinrich Schulze first produced images by the action of light on silver salts. Though Schulze did not make any practical application of his experiment, it is nevertheless the key contribution to photochemistry, which eventually blossomed into photography.

A number of other scientists, including Carl Wilhelm Scheele, J. Senebier, the elder Herschel, J. W. Ritter, and W. H. Wollaston, studied the relative speed of the darkening of silver salts by the various components of the solar spectrum, but none of them applied his knowledge to the production of pictures.

The earliest attempt at photography was made about 1800 by an amateur scientist, Thomas Wedgewood. He tried to fix the images of the camera obscura upon paper or white leather coated with a solution of silver nitrate, but he soon found that he could produce an effect by resorting to the simpler technique of laying leaves and wings of insects on the sensitive material. White images on a dark ground could be formed in two or three minutes in the sunlight, but Wedgewood found no method of preserving the pictures.

The image of the camera obscura was first permanently fixed by Joseph Nicephore Niepce (1765-1833). In the spring of 1816 Niepce succeeded in taking pictures on paper sensitized with silver chloride (22). After experimenting with a large number of light-sensitive substances, Niepce tried bitumen of Judea and consequently developed the world's first photograph.

Niepce also made a number of other contributions to photography. He originated the bellows-camera, the iris diaphragm, and the metal camera, and invented photo-etching.

Louis Jacques Mande Daguerre (1787-1851), a Parisian theatrical designer and inventor of the diorama, also experimented with silver salts. When he heard of Niepce's work, Daguerre immediately informed him that he was working along similar lines. Though Daguerre built on Niepce's knowledge, he considered his work with mercury vapor, making it possible to reduce the exposure to 20-30 minutes, made the final process sufficiently different from Niepce's heliography to justify his naming it daguerreotype. After a period of mutual distrust and negotiation, Niepce and Daguerre joined articles of partnership at Chalon-sur-Saone on December 4, 1829 to last ten years, but Niepce died four years later. The introduction of the daguerreotype process was completely successful and flourished until it was superseded by the collodion process in 1851.

First mention of the Niepce and Daguerre process was made by Francois Arago, then director of the Paris Observatory, at a lecture to the Academy of Sciences, January 7, 1839. At this lecture, Arago proposed the process be purchased by the French government if it were found practical and useful. The complete technical details of the invention were revealed on August 19, 1839--the official birthday of photography--at a joint meeting of the Academy of Sciences and the Academy of Fine Arts.

In 1835 W. H. Fox Talbot (1800-77) had been fairly successful in taking photographs on paper coated with silver chloride. Taken completely by surprise when he heard of Daguerre's work, Talbot hastened to exhibit specimens of his "photographic drawings" at the Royal Institution in London in order to claim priority. On the evening of January 25, 1839, Michael Faraday showed the Talbot samples to the members of the Royal Institution. They consisted of:

> . . . flowers and leaves; a pattern of laces; figures taken from painted glass; a view of Venice copied from an engraving; some images formed by the Solar Microscope and various pictures representing the architecture of my house in the country . . . made with the Camera Obscura in the summer of 1835 . . . (49)

Sir John Herschel immediately became interested in Talbot's work and wrote him a letter dated February 28, 1839, wherein he used the word, photographed. This letter has led to the generally accepted conclusion that Herschel coined the noun, photography.

In the fall of 1840, Talbot invented a modification of his process which came to be known as calotype.[1] The light image was developed with gallic acid, the action of which had been discovered independently by the Rev. J. B. Reade, but no account of his discovery was published. The developed image on a sheet of calotype paper was the exact reverse, as far as light and shade were concerned, of the original image. Such a picture was termed by Herschel in 1841 as a negative.

Since paper is a semi-transparent substance whose transparency can be increased by waxing or oiling on the side opposite to the image, Talbot's process is considered as the first stage in photographic development. Talbot also established the first photographic printing shop and published the first photographically illustrated book, The Pencil of Nature (1844) containing original photographs.[2]

Since glass was cheaper than a silvered copper plate and more transparent than paper, it is surprising that the first practical photographic process on glass was invented as late as 1847. In that year Abel Niepce de Saint-Victor found that the white of an egg (albumen) formed a satisfactory base for the silver salts. Because of its slowness, the albumen process could not be used for portraiture but it served well for architecture, sculpture, and art reproductions. Because of its fine detail, the albumen process remained in favor for several decades for the production of magic-lantern slides and stereoscopic glass positives. The former was introduced by the Langenheim brothers of Philadelphia in 1849 under the name of hyalotypes; the latter by C. M. Ferrier of Paris in 1851.

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[1] Later changed to talbotype at the suggestion of friends.

[2] Until about 1875, pasting photographs on or between the text pages remained the only way of illustrating books photographically.

The wet collodion process, introduced by Frederick Scott Archer (1813-57) in London in March 1851, brought about the first substantial technical improvement in photography and rapidly replaced such older methods of photography as daguerreotypy and calotypy and methods using waxed paper and albumen.

In 1864, W. B. Bolton and B. J. Sayce of Liverpool, England, introduced dry plates, an improvement which revolutionized photography. A further significant improvement which made instantaneous photography possible was made by the invention of gelatine emulsion in September, 1871, by Richard Leach Maddox (1816-1902).

Since glass plates were both heavy and fragile, the use of flexible film as a support was long sought. Various types of stripping had been tried, but nothing satisfactory was discovered until the development of the celluloid film.

Celluloid was invented by Alexander Parkes in 1861 and was first manufactured in 1868 by John Wesley Hyatt of Newark, New Jersey, who used it for the manufacture of solid objects. It was not until twenty years later that celluloid in sheet form became available, and a number of people began to realize that this was the ideal material to use in strip form, sensitized to light, for the recording of movement. Hannibal Goodwin (1822-1900) applied for a patent in May, 1887, for a transparent roll-film made of celluloid, but it was not granted until September 13, 1898. In the meantime a similar film invented by H. M. Reichenbach was put on the market by the Eastman Company, for which the firm was granted a patent in December, 1889. For the next fifteen years, the Eastman Kodak Company had practically a world monopoly in the manufacture of roll-film.

Simultaneously with the manufacture of gelatine dry plates came the introduction of a wide range of gelatine printing-papers. The most important of these was the fast gelatine bromide-paper which was sensitive enough to permit the enlarging of small negatives by artificial light. This revolutionized photographic apparatus because it was now possible to use small negatives in hand cameras, and to make enlarged prints.

The invention which gave the greatest stimulus to amateur photography was the Kodak camera, introduced by George Eastman (1854-1932) in August, 1888. It reduced to three the ten or more operations formerly required to make an exposure, reduced the weight and bulk in the same proportion, and permitted the taking of one hundred pictures without reloading. The Kodak camera was the first apparatus with a built-in roll-film arrangement, measured only 6½ x 3½ x 3½ inches, and weighed only 2 lb. 3 oz. The name Kodak was Eastman's own. "You press the button--we do the rest," became a household slogan.

George Eastman, a former bank clerk, first began as an amateur photographer. In 1879, he invented an improved process for coating dry plates, and registered the patent in England and France, as well as in the United States. In 1880, he invented a second radical improvement in dry plate making and by the end of the year had established himself in business. Eastman made photography universal by creating the largest, all-embracing photographic business in the world. There is no ramification of the art, from astronomical photography to moving pictures, that has not received scientific advancement, leading to important commercial values, from the Eastman Kodak Company of Rochester, New York. In all essentials, the photographic process used today had been perfected by the Eastman Company by 1889.

Woodcuts and Lithography.[3] There is no dispute concerning the invention of lithography. Alois Senefelder gave the facts of his invention in A Complete Course of Lithography (1818). Senefelder, a Bavarian actor, experimented with metal plates, acids, inks, and Solenhofen stone until he perfected the process of lithography. According to his often-quoted story, his mother asked him one day when he was at work, to write her week's washing list, and, paper not being handy, he wrote it with his greasy ink on a smooth stone. Later, instead of cleaning off the writing, he was curious to see what would happen if he etched the stone and pulled a proof. The result was the discovery of relief engraving on stone.

The first successful and continuous venture in the field of the pictorial press occurred when Herbert Ingram published the first issue of the Illustrated London News on May 14, 1842. L'Illustration in Paris and Illustrirte Zeitung in Leipzig followed the News by one year (84). In this country, Frank Leslie published on December 15, 1855, the first number of Frank Leslie's Illustrated Newspaper.

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[3] Wood and steel engraving preceded lithography by many years. At the time of the invention of printing from movable type, the art of wood engraving was already available for crude illustrations. Also, copper and steel were used almost simultaneously for printing pictures.

He modestly admitted in the first issue that "our journal is the most comprehensive and interesting pictorial record of events to be found in either hemisphere." (24) *Leslie's* was followed by *Harper's Weekly* in 1857 in the use of illustration.

The greatest influence exerted upon the illustrative art by photography was through the woodcut. When photography on wood was perfected, it offered a tremendous advancement in the field of woodcut illustration. Closely allied to photography on wood was photography on zinc. This process was originated by Gillot, a Parisian lithographer, in 1859. This method was especially suitable for printing maps, plans, and diagrams. Other modifications of this process were worked out by Louis E. Levy and David Bachrach, Jr., of Baltimore, in 1875 (83). The development of these relatively simple photomechanical processes led naturally to the use of illustrations in daily newspapers As early as 1873, the *New York Daily Graphic* made its appearance as the first American daily newspaper to use illustrations. When Joseph Pulitzer acquired the *New York World*, illustrations were employed for biographical sketches, cartooning, and the picturization of daily news (9).

Up until 1870 there was no successful method of reproducing continuously the intermediate tones between pure black and white by a mechanical process. However, in that year the Alberttype and Woodburytype were invented by J. Albert and Walter Woodbury respectivel A few years later, a far more flexible process known as the *half-tone* was evolved.

Photoengraving. Photoengraving was perfected about 1860. It is based on a curious property of albumen, gelatin, and other colloidal substances. When a suitable film of gelatin, impregnated with potassiu bichromate, is exposed to light, the film tends to become insoluble in water. The degree of indifference to water, roughly speaking, is proportional to the intensity and duration of the exposure to light. This discovery, made by one Mungo Ponton, was applied to the reproduction of line drawings, India-ink cartoons, and similar figures. Although this process of line engraving by photography speedily displaced wood engraving, it was not applicable for views containing large areas of continuous shade and grays, rather than blacks. Some means of breaking up half tones and shades into narrow blacks and whites was supplied when Frederick E. Ives of Philadelphia perfected a screen whereby the half tones and extended whites of the negatives were broken by insertin a multitude of black dots.

Meanwhile, in 1861, James Clerk Maxwell showed that any desired color may be reproduced by a proper mixture of three well-chosen primary colors. In 1881, Frederic Ives made another contribution to photoengraving by perfecting a modification of the half-tone photoengraving process adapted for color printing.

Photolithography. In 1859, J. W. Osborne[4] of Melbourne, Australia, patented his process of photolithography. Photolithography is not directly applicable to shaded pictures, and is based, like almost all photoengraving processes, on the peculiar action of light on bichromatized colloids.

Photogravure. The process of intaglio engraving was first developed by Karl Klietsch of Vienna, who moved to London and there adapted it to cylinder printing, as used in the rotogravure newspaper section of today.

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[4] A large collection of photolithographs and specimens of other photoengraving processes, the gift of J. W. Osborne, is on exhibition in the division of graphic arts, United States National Museum.

Other Processes. A very ingenious and curious method of engraving was perfected by Walter Woodbury about 1864. He printed his negative on bichromated gelatin, and washed away those parts unhardened by light. Thus a structure was formed in which parts corresponding to the highlights of the original subject were washed away, and those parts corresponding to deep shadows were in relief. By hydraulic pressure he forced this structure into suitable soft metal. Good reproductions were made in this way, but it was a costly process and never came into general use.

A gelatin collotype process, which gives the most exact reproduction of the finest detail of any method of engraving, was developed by Poitevin in 1855 and was improved by Motay and Marechal about 1865, by A. Albert of Munich a little later, and by Ernest Edwards about 1872. Like other processes, they awaited the introduction of color screens.

The most useful expedient for laying on tints in drawings and engravings was devised by Benjamin Day in 1879. It consists of a flexible, transparent film, as of celluloid or other similar substance, on the lower side of which is contained a reticulated surface of some design.

Posters. The first posters were the drawings made on cave walls or scratches on the ribs of palm leaves or elephant tusks. Egyptian wall paintings, mural decoration, and inscriptions produced around 3,000 B.C. have been discovered by archaeologists. Tablets of wood, papyrus, and parchment were used in ancient Greece and Rome for the purpose of issuing announcements. In later days, with the rise of trades and guilds, the sign board was adopted as a form of advertisement. These signs or posters were an emblem of the trade of a craftsman.

After the invention of printing, the first letterpress posters made their appearance. In France, a royal proclamation was issued in poster form. The term "poster" came into existence during the sixteenth century. During the seventeenth century, the general use of posters was forbidden, but in time their value to the community was realized, official restrictions were removed, and the first pictorial posters made their appearance. Peddlers, hucksters, and showmen, strolling players and proprietors of booths used handbills and miniature posters which were decorated by woodcuts.

In 1867, the world saw the first modern poster. This poster, invented by Jules Cheret, was an announcement of a fairy play enacted by Sarah Bernhardt. The first Cheret posters excited interest and held one's attention with their flaming colors and their finely drawn figures. Meanwhile, in England, Frederick Walker made a poster called *The Woman in White* which became so famous that it was hung in the Louvre Art Gallery.

Posters began in the United States in the last decade of the nineteenth century when Louis Rhead and Will H. Bradley began to produce their decorative placards. Later, business and commerce saw the value of poster advertising. With the outbreak of the first World War, posters took on a new significance in all nations engaged in the struggle. Posters have been used effectively in both World Wars in recruiting and in appealing to the people in behalf of subscriptions for war bonds, the conservation of food, and aid for war relief organizations. Today, a public opinion is mobilized, propaganda wars are fought, and education is enriched by the utilization of the poster.

Cartoons and Caricatures. The history of cartooning and caricatures dates from prehistoric times. In ancient remains, drawings are found lampooning the foibles of man, especially of the great and pretentious. The modern political cartoon is, however, a by-product of the last century. Probably one of the most famous political cartoons of all time were those of Thomas Nast against the Tweed Ring which ran the government of New York City for its own profit in the 1860's. Nast's work marks the beginning of the modern period of cartooning. Many of his inventions, including the Tammany tiger, the Republican elephant, and the Democratic donkey, have become standard symbols. Nast's cartoons, like those of his great contemporary, Joseph Keepler, the founder of Puck, and most others of the nineteenth century, were personal and often abusive.

The influence of the cartoon upon the formation of public opinion has been considerable. The compactness of presentation and the simplification of issues have had an impact unmatched by long printed editorials.

Comics. Comic books have been published since 1911. However, the reading of them did not become a sociological phenomenon until 1933 when the modern form of comics came into being (36).

Charts and Graphs. The historical development of charts and graphs has stemmed in the main from the graphical representation of statistical data. This has been brought about by the origin of the coordinate principle, the drawing of curves on the coordinate principle, the drawing of curves on the coordinate background, the invention of analytic geometry, the collection of numerical data resulting from observation, and the translation of the numerical statistical data into graphical expressions.

The principle of coordinates was an ancient development, dating from the time of Egyptian surveyors who made use of it in the laying out of towns. Also, the use of a coordinate system as a field of operation for the study of curved lines occurred in the Middle Ages. Early graphical representations resembling modern forms have been found which date from the tenth century.

In 1637, Descartes invented analytic geometry, and soon after, scientists began graphing empirical formulas. In the seventeenth century, Charles Davenant began the first use of graphics for the analysis of economic trends; the thermometer and the barometer came into general use; and meteorological tables began to appear. It is difficult to state with any accuracy the exact date of the origin of the bar graph, but the first recorded use of it was made by Joseph Priestly in a publication of biographical and historical charts after the middle of the eighteenth century.

The father of the graphical method is generally considered to be William Playfair (27). Near the end of the eighteenth century, before the term statistics had appeared in the English language, Playfair published his many examples of the line graph, circle graph, bar graph, and pie diagram. Furthermore, he explained the advantages of these graphs for the discovery and analysis of economic trends. The first example of the graphic method which Playfair called lineal arithmetic is found in his Commercial and Political Atlas of 1786 (68). The first edition of the Atlas contains forty-four charts, all but one of which are broken-line graphs. Also, in the Atlas, the first known use of a bar graph appears. In the 1801 publication of Playfair's Statistical Breviary, the first circle and pie graphs are illustrated.

Playfair exerted little influence until after the middle of the nineteenth century. For the first part of this century the development of new graphic forms and the popularization of the graphic method were largely due to the efforts of the vital statisticians and to the work of French engineers engaged in public works and transportation.

By the middle of the century, the graphic method had become fairly established as an important adjunct in the study of vital statistics and the comparison of surfaces. Meanwhile, two types of cartograms were invented by Charles Dupin, C. J. Minard, Belpaire, and Halley.[5]

The nine International Statistical Congresses held between 1853 and 1876 furthered the development of the graphic method. In the report of the organizing commission of the Budapest Congress, there is among the recommendations the following on the teaching of statistics:

> The knowledge of these elementary notions can be facilitated by diagrams and cartograms. In the secondary and higher instruction as well as in primary instruction, the graphic method ought to occupy a large place. (26)

By 1856, statisticians and educators alike were becoming aware of the instructional values of graphs.[6]

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[5] The pioneers in the invention and use of cartograms were the French. The term cartograms was not coined until sometime in the 1860's. The early designation was carte figurative. The first type, invented by Dupin, is called a cartogram with tints or shaded hachures. The second, called cartograms with bands, was originated by Minard and Belpaire. This consists of colored bands or ribbons which follow the watercourses and railways on a map, the width of the band being proportional to the amount of traffic or number of passengers carried. The third type, invented in 1851, also by Minard, is the cartogram with diagrams in which the center of each geographic division considered is taken as the foyer for a small diagram. The fourth type is the cartogram with contours. Halley in 1701 made a beginning of this type of representation and Phillippe Buache published a contour map in 1752. In 1843, Leon Lalanne gave a graphic translation by means of contours of a temperature table. C. J. Minard, Des tableaux graphiques et des cartes figuratives (Paris, 1861).

[6] Lavasseau began to introduce diagrams into his geography textbooks in 1865, but there is little evidence that any appreciable use of graphs was made in textbooks before the beginning of the twentieth century. However, by the middle of the nineteenth century, graphic displays began to appear at expositions, and graphs began to be used in government and industry publications. The Mutual Life Insurance Company began to use graphs in 1859, and in 1873, a Statistical Atlas of the United States included sixty plates of illustrative graphs. In 1872, H. P. Bowditch of the Harvard Medical School exhibited numerous diagrams before the Boston Society of Medical Sciences which showed the rate of growth in height of the two sexes. Florence Nightingale also used the graphic method as an effective aid in her campaign to improve sanitary conditions.

Near the end of the nineteenth century, the first pictorial statistics were developed by Michael George Mulhall. Otto Neurath has been widely credited for this achievement, but a cursory examination of Mulhall's publications would leave little doubt on the matter.[7] In Mulhall's History of Prices since the Year 1850 (1885), there are a number of diagrams colored in buff and blue. One such diagram represents the proportion of taxes to earnings in various states. On the same page, there are squares of light blue which represent the ratio of debt to national wealth in the principal countries of Europe and in the United States. In another portion of the book, little buff and blue colored sailing vessels are shown representing the total tonnage of the mercantile navies of the world. There is even greater variety in Mulhall's Dictionary of Statistics (1884):

> At the word Army we find quite a battery of little guns delicately colored in pale pink and green; at the word Cattle a herd of oxen, green and pink; at the word Houses quite a street of little buildings again colored in green and pink; at the word Railways a train of coaches, green and pink. (25)

The first known pictographs were published in this country in Willard Brinton's Graphic Methods for Presenting Facts (1914).[8] In the early twenties, Otto Neurath's highly propagandized Vienna Method made a contribution to pictorial statistics in its development of a standardized symbolism for the pictures and hieroglyphics suggested and used by earlier writers. Another aim of Neurath was to develop an international pictorial language, which he called Isotype (International System of Typographic Picture Education). Due to the inspiratio
of Neurath's ideas, Pictorial Statistics, Inc., was formed in New York in 1934 (60).

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[7] Another forerunner of the Vienna Method of Otto Neurath was Jacques Bertillon. He was the first to suggest that colors and symbols can serve to recall the legend.

[8] Some of the earliest courses in graphic representation were offered at the Massachusetts Institute of Technology, Iowa State College, and Stanford University.

Maps and Globes. Maps have been made since ancient times. Early wandering tribes and explorers used the map as their guide. The Egyptians were famed as geometers, and as early as the days of Rameses I, a cadastral survey was made of the country showing on a map the rows of pillars which separated the names as well as the boundaries of the landed estates. Anaximander has been credited with designing the first map of the world. We learn from Cicero, Seneca and others that the Romans had both general and topographical maps. In ancient China, maps were engraved on bronze or stone. During the Renaissance, Leonardo da Vinci devised the mappemonde from a Portuguese globe and, by dividing the globe into eight sections, anticipated the Butterfly or Global Gore map. Mercator's invention of his cylinder projection inaugurated the beginning of modern maps. Mercator's successors later devised such variations as the conic, polyconic, sinusoidal, and azimuthal projections.

Crates (150 B.C.) is said to have built the first globe. The oldest terrestial globe extant was constructed by Martin Behaim of Nuremberg in 1492. Globes, both celestial and terrestial, became popular after voyages of Columbus, Magellan, and the Polo brothers; and were used for instruction at the University of Vienna in 1501. In 1507, Waldseemuller published a small globe with printed segments or gores. Later, A. Durer and H. L. Glareanus were the first to deal scientifically with the principles of globe construction.

The Chalkboard. The chalkboard, or more commonly the blackboard, is a modification of the Roman waxen tablet, the hornbooks of the Middle Ages, and the slate of more recent times. The first edition of the Orbis Pictus (1658) of Comenius illustrated a schoolroom with a blackboard, but it is not precisely known when it was first used.

Models and Mock-ups. The making and use of models is as old as mankind. In ancient times, the Egyptians believed that their human spirit, after death, was incapable of crossing bodies of water. Therefore, they buried a model boat with their dead so that the soul might be assisted across the river. An early model dealing with steam was built by Hero of Alexandria about 120 A.D. Another early model of the steam engine was made by James Watt. Later, William Murdock joined Watt in making what was probably the first model locomotive.

Representations and Displays. Modern technology has made possible the development of many new three-dimensional materials that aid in learning and understanding. Representative of these materials are such items as sand-table reliefs, carvings, miniatures, various synthetic devices, models and dioramas. While it is true that some of these representations antedate the full flowering of the industrial revolution, the inventive genius of modern man has made it possible to reshape and refine many of these displays.

Projected Still Pictures

The forerunner of the modern stereoscope, filmstrip projector, opaque projector, micro-projector, slide projector, overhead projector, and tachistoscopic projector was probably the Magia Cataprica or magic lantern of Athanasius Kircher. In 1646, Kircher described the first recorded demonstrations of a magic lantern. His lantern, complete with source of light, reflector, and lens, was used to project images of devils and demons on the wall. He changed his pictures rapidly by painting them on a revolving glass cylinder. A few years later, de Charles improved the instrument; and in the eighteenth century a Dutchman named Musschenbroek made it possible to simulate motion by using two superimposed slides. Aside from its effective use in the classroom, the lantern "offered a consecrated alternative to the carnal attractions of the theater and the circus." (38)

The Stereoscope. More than two thousand years ago, Euclid discovered the principle of stereoscopic vision. When C. Wheatstone first observed a stereoscopic effect, he was stimulated to construct a mirror stereoscope in 1838, just a year prior to the announced photographic achievements of Daguerre, Talbot, and Herschel. Scientific circles received his invention with delight, but it could not be utilized very effectively because all pictures had to be made by hand. The preparation of photographic prints suitable for stereoscopic examination had not yet been made. It was not until 1845 that Wheatstone completed the first successful experiment in viewing and fusing two photographs of the same scene, made from slightly different points of view (34).

Other mirror stereoscopes were made by H. W. Dove, Sir David Brewster, and others, but it remained for Oliver Wendell Holmes to refine the stereoscope in 1859 and bring about its popularization in the United States. In 1850, the first stereoscopic views produced by the camera were introduced into the United States by the Langenheim Brothers of Philadelphia. Their early attempts to produce this type of photograph were made from albumen negatives and printed on glass, which was also coated with albumen. These prints were not only used as stereographs, but as slides for the magic lantern. In 1855, the Langenheims interested a group of Philadelphia businessmen in financing the first extensive photographic expedition for the purpose of securing a collection of representative American views, to be reproduced as stereographs. The expedition began at Philadelphia and "followed the south route of the Reading, Catawissa, Williamsport and Elmira Railroad to Niagara Falls." These early Langenheim stereographs were the forerunners of the stereographs which later appeared in American homes and schools in the latter part of the nineteenth century and the early decades of this century.[9]

The Slide Projector. The magic lantern was the ancestor of the modern slide projector. Until the time of Daguerre and Niepce, slides were hand-painted. Coal-oil lamps and hydrogen or calcium lights were common sources of light. Through the years, many attempts were made to simulate motion in projected pictures by means of "slip slides," dissolving views and levers. Both Edison and Lumiere experimented with the lantern projector prior to their work on the motion picture. The term stereopticon came into common use during the late nineteenth century.

Slide Film Projector. There is considerable doubt as to who should receive credit for the invention of the slide film projector. As early as the spring of 1914, the New York optical firm of Herbert and Huesgen demonstrated a photographic device called the Tourist Multiple Camera which took 35 mm film which could be used in a special type of projector. The separate projector did not even have a specific name and was clearly assigned a subordinate role. On December 24, 1914, patent specifications for a slide film projector by Maurice G. Ricker and Morton A. Bassett were witnessed, and the complete specifications were filed on January 8, 1915. John R. Bray, often credited with the invention of the slide film projector, has stated that he invented and developed the first slide film projector, but the earliest date of his Brayco is 1918. Even though the Brayco was not the first slide film projector, it proved to be cleverly constructed, nominally priced, and eventually inspired Jam Handy to design a similar slide film projector which he used to launch his successful Jam Handy Picture Service in Chicago for industrial clients. In 1931, the first synchronized sound recordings were made to accompany the slide film.

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[9] The Langenheims formed the American Stereoscopic Company, one of the first large producers of stereographs. Also, the Langenheims deserve the credit for introducing stereograph and magic lantern slides in the United States. It is interesting to note that magic lantern slides were called stereopticon slides and were consequently often confused with stereographs. (Photographic Art Journal, 7:320, 1854).

The Tachistoscope. There is evidence that the tachistoscope (swift view) was in experimental use as early as 1844. Sir William Hamilton did much of the first crude experimental work on perception in 1859. The first step toward experimental control was taken by Jevons in 1871. The tachistoscope was later more fully developed in the early German psychological laboratories of Wundt and others. In 1895 the mechanism was adapted by Cattell for use in span and reading experiments. In this same year, Catherine Aikin wrote a book in which she advocated a method of instruction for the development of rapid, accurate perception. In spite of the prevalent skepticism and controversy aroused by her book at the time, one can easily see that she anticipated modern tachistoscopic training. By 1910, Whipple had developed a tachistoscope for classroom use, and in 1930, one of the first modern improvements had been made by Samuel Renshaw of Ohio State University. During World War II, tachistoscopes were used in aircraft identification. Since the war, they have been used in remedial reading programs and in vision training.

Microfilms. When Paris was besieged in 1870 during the Franco-Prussian War, a photographer named Dagron, under the stress of the moment, invented a process of photographing messages on collodion or wet-plate emulsion. After the war, the process was generally forgotten until the 1936 Richmond conference of the American Library Association. While considering an exhibit for the 1937 French Exposition, it occurred to some members of this organization that Dagron's earlier achievement would make a noteworthy contribution. This prompted an organization of a committee on Photographic Reproduction of Library Materials, and by December, 1936, a microphotography laboratory was established at the University of Chicago. Meanwhile, the Eastman Kodak Company developed an appropriate camera for microfilming, and the United States Department of Agriculture began its Bibliofilm Service. By May, 1937, the first public demonstration of microphotography was held at the Paris Exposition.

Motion Pictures

The history of the motion picture is synonymous with the birth of human expression. It began from the time when man first endeavored to transmit emotional stimuli and recreate experience by tracing crude pictographs and carving strange sculptural figures on the walls of his cave. Even though the stylus and chisel could not attain his ideal of motion, he attempted to visualize it by moulding a cavalcade frieze on the walls of the Parthenon. From the days of Aristotle, one can find fragments of ideas groping toward the motion picture. Notably, Leonardo da Vinci's Trattato della Pitture is filled with the wish for pictorial reality.

The Forerunners. The phenomenon of the persistence of vision was undoubtedly observed by prehistoric men. Many early philosophers, scientists, and literary men discussed it. The Roman poet Lucretius noted the fact of persistence of vision in his Rerum Natura and Ptolemy wrote in his second book on optics, written about A.D. 130, that he had observed a spot of color to form an apparently continuous circle when revolved.

The achievement of an illusion of motion was the fundamental discovery in the history of the motion picture. In 1646, Athanasius

Kircher published Ars Magna Lucis in which he gave the first recorded description of the magic lantern. In this same book, Kircher described a revolving glass cylinder device which may have contributed to the later invention of the zoetrope.[10]

In 1824, Peter Mark Roget, author of the famous Thesaurus, presented a paper on The Persistence of Vision with Regard to Moving Objects before the Royal Society of Britain.[11] Roget was stimulated to experiment with the idea of creating motion in pictures when he caught a glimpse of a passing baker's cart through the slits of his Venetian blind. He had the visual impression that each distinct, fleeting image of the cart and horse was arrested in successive phases of motion and that certain spokes of its wheels seemed curved. Leonardo da Vinci and Isaac Newton had also been fascinated with this problem, but Roget probably made the first scientific investigation into the phenomenon of illusory motion.

The work of Roget inspired others to make experiments with motion. Sir John Herschel and Michael Faraday were among those who engaged in this early experimentation. Others developed twirling disc devices simulating motion. A Dr. William Fitton drew a bird on one side of a paper disc and a cage on the other. When this disc was attached to a stick and revolved, the bird appeared to be sitting in the cage. Beginning about 1826, another English physician, a

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[10] Wheatstone, the inventor of the stereoscope, announced almost simultaneously that "a series of brief illuminations make it possible for a moving object to seem immobile." Lancelot Hogben, From Cave Painting to Comic Strip (New York: Chanticleer Press, 1949), p. 253.

[11] Someone known only as "J. M." wrote a letter to a learned journal in Great Britain and reported his observations concerning the "persistence of vision." (in 1820) Kenneth MacGowan, "The Coming of Camera and Projector--Part I"--The Quarterly of Film, Radio and Television, Volume IX (Fall, 1954), No. 1, University of California Press, p. 3.

Dr. Paris, developed a number of designs on similar discs and called his toy the Thaumatrope (magic turning). Joseph Plateau, a blind Belgian physicist, who developed the stroboscopic method of studying the motion of a vibrating body invented a device called the Fantascope (phantom view); and Simon Ritter von Stampfer of Vienna developed a Stroboscopic (whirling) Disc. These were later supplanted by a commercial device called the Phenakistoscope (deceitful view). In 1834, William George Horner of Bristol invented what was later known as the Zoetrope. In Horner's wheel of life toy, slots were arranged around the top on a rotating hollow cylinder with drawings of paintings around the inside of the cylinder on the bottom.

First Projected Movement. None of the early devices could achieve continuous movement. The first device for throwing moving figures on a wall was invented about 1852 by an Austrian ordinance officer named Baron Franz von Uchatius.[12] His so-called lantern wheel of life in effect wedded the magic lantern to the zoetrope. The result was a projected moving picture, but a weak lamp and a shutter produced a blurred image at a distance of more than six inches. The following year, Uchatius eliminated the shutter and substituted a powerful limelight. A stationary disc carried the picture with a lens behind each of them. The limelight, with condensing lens in front of it, revolved behind the picture disc and projected large, clear images on a wall.

Another variation of the zoetrope was the Praxinoscope in which a mirror, made up of several facets, was used in the center of a rotating solid cylinder. The pictures were painted on the inside of the cylinder and one facet of the mirror caught each picture as the cylinder was revolved.

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[12] Eight years before Uchatius showed his invention, an Austrian field marshal recognized that moving pictures could be used as a teaching aid and asked Uchatius to develop his idea as a means of military instruction.

All of these methods except the praxinoscope caused a distortion of the images. When the images moved in the same direction as the slots, they appeared to be widened. When the slots and images moved in the opposite direction, they appeared to be narrowed. Some of these defects were subsequently corrected by the British physicist James Clerk Maxwell when he arranged the viewing slots in the zoetrope with lenses. A resultant blending of the images in the center of the revolving cylinder without an accompanying distortion was achieved.

By 1860, photography had progressed to the extent that short exposures could be taken, but not fast enough to record objects in motion. In 1861, Coleman Sellers of Philadelphia invented a machine called the kinematoscope. This machine consisted of various pictures arranged around an axis, much like the paddles of a water wheel. The pictures were viewed through a device like the eyepiece of a stereoscope and were turned by a knob. It is interesting to note that the name kinematoscope was the first use of the Greek root for motion and is a direct ancestor of the word cinema.

Wenham, an Englishman, in 1852 and Desvignes, a Frenchman, in 1860 were apparently ihe first men who attempted to photograph separate states of objects in motion and to reconstruct their movement on revolving discs without projection. A complete anticipation of the motion picture was embodied in a patent application by Louis Arthur Ducros du Hauron in France in 1864. A device called the kineograph was patented by Linnett in 1868. In this invention, successive pictures of a single action were made into a little book. When the edges of the book were thumbed rapidly, each page brought the pictures to view in rapid succession and the illusion of motion was created.

When photographs were used instead of drawings, the device was repatented and called the kinetoscope.

In 1870, the Sellers method of photographing posed phases of motion was applied to a projecting zoetropic device by Henry Renno Heyl of the Franklin Institute of Philadelphia. This device, known as the phasmatrope, was the culmination of the contributions of Plateau, Stampfer, Uchatius, and Daguerre. At this time, the motion picture had been attained and was complete in every detail except for the instrument of record. It was still necessary for the camera to acquire the ability of making the basic record negatives at the speed of reality.

The next vital evolutionary step in the development of the motion picture occurred in California. It is widely known that Governor Leland Stanford is reputed to have made a $25,000 wager that in a gallop, all four feet of a horse are off the ground at once; that he hired one Edward Muybridge, a world famous photographer, to prove it with pictures. It is less commonly known, however, that Muybridge failed in his efforts and was about ready to give up when a personal incident in his life interrupted his work completely on October 17, 1874. It was on this day that Muybridge murdered his wife's lover.

The two day trial that followed at Napa brought about an acquittal on a temporary insanity plea, but he withdrew from society for the next three years and lived in the hinterland ranch property of Leland Stanford. In 1877, Muybridge again returned to his experiments. After almost desperate attempts, Muybridge obtained four significant pictures, one of which indistinctly showed a horse with all of his feet off the ground. At this juncture, Stanford became impatient and turned the problem over to John D. Isaacs of the Central Pacific Railway. Isaacs worked out a system of electrical contacts with wire stretched at intervals across Stanford's race track at his Palo Alto stud farm. Thus, the photographic system of Isaacs eventually enabled Muybridge to enjoy all the fame and prestige growing out of the achievement of capturing the movements of a galloping horse.[13]

Later Muybridge fastened a series of galloping horse pictures on the edge of a disc so that:

> . . . picture after picture comes into view but a moment, we are able to see the horse galloping as in nature, stride succeeding stride, every circumstance of the motion, even to the waving of the tail and mane, being truthfully, and therefore naturally, recorded. (74)

When a famed Parisian artist by the name of Meissonier heard about the Stanford pictures, he prevailed upon Muybridge to come to France because he was in a heated controversy with French academicians over the postures of horses in his pictures. They were finally confronted with the photographs, and as final proof Meissonier synthesized the photographic analysis into motion pictures by projecting transparencies on a Heyl-designed machine christened the Zoopraxinographoscope by Muybridge. This event which occurred about 1880, marks the first application of true photographic records of motion to a zoetropic device. Although this machine was not very efficient or practical because of the inherent faults of glass plates and cumbersome equipment, it did provide the incentive for more skillful technicians. Successive photography reached its peak in Muybridge's work and stimulated efforts all over the world to solve the remaining problems of the motion picture camera, the projector, and the photographic material itself.[14]

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[13] Terry Ramsaye, A Million and One Nights (New York: Simon and Schuster, Inc., 1926), p. 21. Robert Taft disputes this point, but he does not offer any evidence which invalidates Ramsaye's report. See Robert Taft, Photography and the American Scene (New York: The Macmillan Co., 1938), p. 509. The University of Southern California has a film with the original Muybridge pictures on the animation stand so that movement is achieved.

In France, in 1882, Marey produced a workable camera in the form of a gun; and by using glass plates, he successfully caught the movement of birds in flight, fishes moving in a stream, and a cat, in slow motion, turning over and landing on its feet. With the invention of methods of making continuous bands of celluloid film by Hyatt and Eastman in the middle eighties, camera inventions came in rapid succession--Marey in 1887-88; Friese-Greene,[15] Leprince,[16] Edison and Dickson in 1888. In June, 1889, Friese-Greene took out his patent for a camera; Reynaud used perforated film the same year; and in 1890-91, Edison perfected the system of perforation which remains standard to this day. The projection of film, which had not been accomplished experimentally by such early pioneers as Friese-Greene, Edison, Dickson, and Leprince, was first satisfactorily achieved in 1895 by Armat, Jenkins, and LeRoy in the United States and by the Lumieres in France.

Development of Motion Picture Projectors. After Thomas Edison had completed the phonograph in 1877, he began to attack the problem of motion pictures. His first motion picture machine recorded spirals of tiny pictures on a cylinder, in the pattern of a phonograph groove. The pictures were given an intermittent motion and were viewed under a microscope. Edison soon abandoned this method because of the problems of magnification. He then conceived the idea of images being handled on a tape or belt. Experimental films were made by drying collodion varnish coated with photographic emulsion on glass and stripped off into sheets. This material was unsatisfactory because of the fragile quality of the films. In August of 1899, George Eastman, who was seeking similar material for the purposes of roller photography, began the manufacture of photographic film with a flexible nitro-cellulose base.[17] Edison heard of this material and purchased a sample 50 foot strip and found that his problems were solved.[18]

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[14] The astronomer Pierre Jules Cesar Jannsen in 1874 succeeded in making the first practical motion-picture camera in order to record the passage of Venus across the surface of the sun. His camera was based upon the earlier work of Uchatius and Daguerre and used only the intermittent motion principle of the modern camera. With this camera, which used a revolving shutter and a photographic disc, Jannsen was able to make forty-eight exposures on a disc and to stop them at the desired moment. Ibid.

[15] Friese-Greene used celluloid film as early as 1885, experimented with three dimensions and developed an early color process similar to Kinemacolor, but after twenty years of comparative obscurity he fell dead just as he concluded a speech during a public dinner at which British film makers honored him. Only one shilling and ten pence were found in his worn old purse.

[16] Leprince became a dramatic figure in motion picture history when, in 1890, he boarded a French train with his camera-projector, and neither he nor his machine was ever seen again.

Less than two months later, on October 6, 1889, the first model of the Edison Kinetoscope and the parent of the modern motion picture art was demonstrated at the Edison Laboratories in West Orange, New Jersey. The Kinetoscope was a peep-show device in which the film ran with a continuous movement between a magnifying lens and a light source. The machine had a total capacity of about 50 feet of film.[19] The film was about one inch in width and presented sixteen frames or about forty-six exposures a second. The Edison standard size of the film, the image, and the arrangement of the sprocket holes by which the film was driven into this first machine remains the world standard of today.

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[17] Rev. Hannibal Goodwin simultaneously invented a film base to take the place of glass plates. A complex controversy arose between Eastman and Goodwin when an infringement suit was brought against Eastman in 1902 by the Ansco Company.

[18] An important stimulus in the invention of celluloid was the impending crisis in the billiard-ball industry brought about by the world shortage of ivory. Hyatt, an Albany printer, in the process of making a substitute substance for billiard balls obtained celluloid.

[19] This was determined by the fact that George Eastman supplied photographic film in that length.

After its invention, the Kinetoscope was pushed into an inauspicious corner because it no longer stimulated the interest of Edison. It stood idle in the Edison laboratory until it came to the attention of Thomas R. Lombard of Cornelia, Georgia, who was a promoter of the phonograph. Lombard secured a reluctant agreement from Edison to let it be commercially introduced at the opening of the Columbian Exposition in Chicago. However, the production of the machines was not ready for the exposition. The first public showing of the machine occurred at the Kinetoscope Parlor at 1155 Broadway, in New York, on April 14, 1894. Simultaneously, the commercial history of the motion picture began.

The Kinetoscope subjects were portions of variety show acts, and the feats of acrobats, dancers, and trained animals. The pictures for the Kinetoscope were produced at West Orange, New Jersey, in a tiny revolving studio dubbed _The Black Maria_ because it was covered with black tar paper. The Kinetograph, or camera, was almost a ton in weight and all events had to be brought up to it.

By the winter of 1894, a demand arose for a machine which could combine the Kinetoscope's film record with the magic lantern so that the picture might be freed from the peep-show. Edison had experimented in projection, but he hampered the development of the idea of mass projection because he felt that large audiences would exhaust the novelty of his pictures too rapidly. However, in the meantime, other men began to attack the problem of projection.

The earliest projectors were theatrical machines adapted for booth projection in auditoriums. Because of their size and cost, these projectors were later supplemented by portable and semi-portable types of lower price, available under proper protection, for classroom use in 35 mm. At the same time quite a variety of sub-standard motion picture projectors appeared, some for 28 mm or less. Out of this array of confusing sizes, it became evident that the 16 mm combined the qualities of economy, portability and safety to the greatest degree and it began to be adopted universally for narrow-width projection.

In 1894, Gray Latham and Otway Latham formed the Kinetoscope Exhibition Company with Rector and Samuel J. Tilden, Jr., and produced a fight picture in six rounds. Six Kinetoscopes were used to show the films; a round to a peep-show. This project was so successful that the enthusiasm of the Lathams was stimulated for the development of mass projection. They envisioned the time when the Kinetoscope could be combined with the magic lantern so that a picture might be projected on a wall in order that an entire audience could see a picture simultaneously. An appeal to their father, Major Woodville Latham, initiated an experimental work-shop. On February 22, 1895, Major Latham gave a New York press exhibition of his pantoptikon, projecting a kinetoscopic film. However, when the machine was placed on public exhibition, it was highly imperfect in principle and performance.

A second version of this device had a brief international career under the name of the eidoloscope. Meanwhile, pressure was being simultaneously exerted upon Edison by Norman C. Raff and Frank R. Gammon of the Kinetoscope Company for a projection machine, but Edison was reluctant to disturb the profitable sale of the peep-show Kinetoscopes.

It was becoming clear that many men throughout the world were beginning to possess an enthusiasm for the idea of motion picture screen projection. In London, Robert Paul, a maker of scientific instruments, found that Edison had only patented his Kinetoscope in the United States and set to work building his own kinetoscope and designed it for Edison 35 mm film. In the meantime, steps were taken by Edison to cut off his supply of film to Paul's machines. However, Paul had long recognized the limitations of the peep-hole viewing arrangement and had set about building a new projector which he called the Animatograph. This machine, first tested in the early months of 1895, was probably the first to use a picture gate and intermittent movement as we now know it. Since Paul's customers were becoming world-wide, Paul was also forced to build a camera and produce his own films when Edison put an embargo on his film supply. It is interesting to note that it was just at this juncture that Edison decided to withdraw from the English market because of the persistence and ingenuity of Paul.

Almost simultaneously, Louis and Auguste Lumiere, French manufacturers of photographic materials, took out a French patent on February 13, 1895, for the Lumiere Cinematographe. This project included in one machine the earlier discoveries of the disc shutter and intermittent movement together with flexible film. The film was 35 mm wide and had one round hole on either side of the frame; the holes were spaced 20 mm apart.[20] The Lumier machine was an excellent illustration of mechanical design which utilized a filmstrip 17 meters long rather than the Edison length of 40 feet.

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[20] Three years later, Edison perfected a better projector and gave steadiness to the picture by the use of four sprocket holes on the side of each separate frame instead of one.

The Cinematographe was first demonstrated on March 22, 1895, in Paris and June 10, 1895, in Lyons. On December 28, 1895, a successful public Cinematographe show was opened in the basement of the Cafe de Paris. Lumiere projectors were first introduced in the United States in the autumn of 1896 when a Mr. Hurd, agent for the Lumieres, projected a picture 22 by 16 feet. As a result of this demonstration, Mr. Hollaman, manager of the Eden Musee, signed a contract for the projector's installation. Unfortunately for the Lumieres, however, it soon became apparent that they would have to alter their projector if it were to accommodate the Edison films. When this was subsequently done, the first practical international standardization of motion pictures had been accomplished.

The Vitascope. An important contribution to the development of the modern projector was made by Thomas Armat and C. Francis Jenkins. Jenkins has related the story of the invention of his projector in the following words:

> I began working on the development of an apparatus for recording and reproducing motion in 1890 and the film I used in my first camera and projector and subsequently was kodak film purchased in the local photo supply shops, slit and joined into long, narrow ribbons by cementing with collodion. My first exhibitions were in 1892, private affairs. My first public performance of which there is any newspaper or written account was held on June 6, 1894 at Richmond, Indiana. (77)

This first exhibition, of which Jenkins speaks, was historic not only because it was the first showing of motion pictures, but because it was also the first showing of colored films. The subject of the film was a butterfly dance and each frame had been patiently colored by hand.[21]

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[21] This first exhibition of which Jenkins speaks is subject to dispute. A newspaper account cited by Terry Ramsaye states that Jenkins gave an exhibition of motion pictures in his brother's jewelry store on October 29, 1895. Since Thomas Armat and Jenkins had exhibited their projectors previous to this date at the Cotton States Exposition in Atlanta, Georgia, the exposition at Richmond, Indiana, cannot be considered the first public showing of motion pictures if Ramsaye's citation is accurate.

In March, 1895, Jenkins and Thomas Armat entered into a partnership. It was also about this time that these two men discovered the basic projection principle of intermittent motion for the film.[22] At the Cotton States Exposition in September, 1895, Jenkins and Armat publicly exhibited their projectors. An admission price was charged and the first movie fans came into existence. Unfortunately, however, a fire destroyed the equipment and eventually caused the ultimate parting of these two men. In the meantime, Norman C. Raff and Frank R. Gammon of the Kinetoscope Company of New York, were attracted by the success and performance of the Jenkins-Armat machine. In 1896, Armat and Edison made an agreement for the making of an improved projector under the name of the Edison Vitascope. The Vitascopes were manufactured at the Edison plant in West Orange, New Jersey.

The commercial career of the motion picture on the screen began with the presentation of the Vitascope in a showing at Koster and Bial's Music Hall, in Herald Square, New York, the night of April 23, 1896. The New York Times described the premiere of screen history for the United States as follows:

> When the hall was darkened last night, a buzzing and roaring were heard in the turret and an unusually bright light fell upon the screen. Then came into view two precious blonde young persons of the variety stage, in pink and blue dresses, doing the umbrella dance with commendable celerity. Their motions were all clearly defined. When they vanished, a view of the angry surf breaking on a

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[22] There is also some dispute about the invention of the intermittent film movement principle. Ramsaye credits Armat with the invention of this principle and states that he was the first to apply it to the projector. An endless controversy eventually erupted between Jenkins and Armat when the question of priority on patent rights was contested. Jenkins, aided by certain events and the prestige of the Franklin Institute, was finally accorded the honor of invention. However, Ramsaye makes the observation that the first modern projector was really the product of the joint efforts of Armat and Jenkins and that if differences between these two men had not arisen, the question of priority would not now exist.

> sandy beach near a stone pier amazed the spectators. . . . A burlesque boxing match between a tall, thin comedian and a short, fat one, a comic allegory called "The Monroe Doctrine," an instant of motion in Hoyt's farce "The Milk White Flag," repeated over and over again, and a skirt dance by a tall blonde completed the views, which were all wonderfully real and singularly exhilarating. (42)

The Vitascope was made available for entertainment purposes on a state's right or territorial basis. However, when competitive domestic machines came into existence, the territorial purchasers of the Vitascope became oblivious of their boundaries. Even before a commercial structure could be established, there was a threat to its stability.

In 1895, William Kennedy Laurie Dickson, formerly an associate of Edison and Latham; H. N. Marvin, an electrical engineer; and Herman Cassler, a machinist, formed the K. M. C. D. Syndicate. From this organization came the Mutoscope, peep-show machine similar to the Kinetoscope which used a cartwheel instead of film, and the Biograph, a projection machine that used a wide film about eight times the area of the Edison standard. The Biograph was presented to the public at Hammerstein's Music Hall in New York on October 12, 1896.

While the Vitascope was being sold on a state's right plan, the Edison Kinetoscope was sold on the open market, and the Biograph was neither sold nor leased. It aimed particularly at the vaudeville theater market by supplying the machine, films, and operator. The exceptional size of the Biograph film was an important factor in determining the selling policy. The Biograph film was so expensive that it could not hope to compete except in large theaters. Also, the mechanical characteristics of the Biograph tended to limit its distribution. The film was driven by friction rollers and cams which was an attempt to evade the Edison patent specifications. In contrast to the relatively simple operation of an Edison or Armat projector, the Biograph had to be run by a skilled operator. Even though the Biograph was technologically of no great importance, it eventually played a significant role in creating the competitive force in the development of the motion picture industry.

Other Early Projectors. In 1898, Sears Roebuck Company marketed a home projector called the Optiscope. Later, Don Bell, a projectionist, used the Optiscope as a basis for developing his Kinedrone before he went into partnership with Howell. In 1908, Francis B. Cannock developed the Edengraph; a year later Richard Hollaman and Edwin S. Porter invented the Simplex professional projector. Other projectors produced at this time were the Kinox (German), and the Pathescope (France).

The first projectors made for the schools were the 35 mm projectors. However, due to excessive cost of films, expense of transportation, and size and weight of machines, 35 mm projectors were never used to any great extent. The first projector to attain non-theatrical fame was the 35 mm Power Cameragraph manufactured by the Nicholas Power Company of New York. This projector was still a rather heavy machine, but it was much lighter than the theatrical type of projector then in use and it projected a brilliant picture. Aside from his projector, Nicholas Power developed the first automatic fire shutter, flame shield, and fireproof magazine. All of these innovations were of great importance to the non-theatrical field in the early days when fire hazards were a constant problem.

The basic requirements demanded of these projectors were that they had to be simple, economical, and portable. The Edison Home Kinetoscope met these requirements to a considerable extent. However, a series of fires at the Edison laboratories eventually discouraged the further production of these projectors. Perhaps, the Acme (1917) projector satisfied the demands of the non-theatrical exhibitors more than most projectors on the market at that time. It was a so-called "suitcase projector" with a shorter throw than a Power Cameragraph, but it cost only half as much. Its principal feature was that it could be threaded easily. Other types of suitcase projectors were the DeVry "E" Model (1913) and the Victor Animatograph (1909). A non-theatrical projector named the Graphoscope stood midway between the professional and suitcase machines as far as portability was concerned. With the introduction of sound, R. P. May of RCA developed the first non-theatrical 16 mm sound projector in 1930.

Technical Improvements. As motion picture technology progressed, many technical innovations and improvements were made. As a result, this continuous technical refinement eventually transformed the motion picture from a crude, flickering mechanism to one of spectacular precision.

Perhaps, the most significant technical achievement in the history of the motion picture was the introduction of sound. As early as 1887, Thomas Edison was stimulated to develop the motion picture largely because he wanted to have pictures synchronized with his newly invented phonograph. Two years later, Charles Pathe and Oskar Messter tried without success to combine motion pictures with a German talking machine. Between 1896 and 1900, a number of French inventors attempted to link phonograph records with motion pictures. However, all these early attempts failed because the recording mechanism was not sufficiently sensitive. Many early experimenters therefore, attempted to wed sound to the film. It was not until 1918 that some of the problems of sound via light were solved before the recording and reproducing of sound on film could take place. Fleming's thermonic valve and DeForest's audion vacuum tube provided the basis for the development of electronic amplification. As early as 1920, Charles A. Hoxie of General Electric demonstrated sound on film in one of its laboratories. Between 1920 and 1922, research engineers of Western Electric made an animated sound film. In 1926, music was synchronized to the mood and action of film. Two years later, this was followed by the synchronization of sound to screen dialogue.

In the early days of the motion picture, there was a disconcerting variety of film sizes. Equipment and films were offered in widths of 9.5 mm, 11 mm, 15 mm, 16 mm, 17½ mm, 21 mm, 22 mm, 23 mm, and 35 mm. But besides the variations of width, projectors had different methods of propelling the film through the gate.

Competition was the principal factor in this remarkable diversity of sizes, but the result was a paralysis of the film market. Schools had no incentive to use motion pictures as long as a projector could show films of only one producer. Consequently, in 1923, the Eastman Kodak Company, the Victor Animatograph Corporation, Bell and Howell, and others agreed that educational films should be standardized at the 16 mm width and should be on non-inflammable stock. The theatrical field adopted the 35 mm film as its standard.

Many novel technical developments occurred in the early years of the film. In 1883, the eminent French physiologist, Etienne Jules Marey established at Paris an atelier for the study of animal motion. About 1904, M. Nogues of the Marey Institute built a camera capable of taking 240 pictures per second, the normal rate then being sixteen. Out of this same institute came the first slow-motion, ultrarapid, X-ray, time-lapse, and micro-photographic films.

Meanwhile, motion pictures in the air were considered from the beginning of modern aviation. In December, 1903, the Wrights made their first successful flights at Kitty Hawk; soon afterward

J. Stuart Blackton of Vitagraph produced some films of this flight. About 1911, Eustace Hale Ball staged a scene involving two airplanes circling about the Statue of Liberty. In April, 1913, Essanay camera men took pictures from a balloon crossing the Apennines. In 1915, a news camera man, strapped to an airplane, took pictures of the retreat of the Serbian Army before the forces of the Austro-German Army. The history of submarine motion pictures begins early in 1913 when Captain J. E. Williamson of Norfolk, Virginia, developed the first telescopic, collapsible tube for photographing under water.

Motion picture photography through the microscope was perfected by Dr. Jean Comandon, a Parisian bacteriologist. A microscopic film by Comandon called, "Sleeping Sickness" was released in 1910. Somewhat earlier, in 1908, F. Percy Smith of England had made some magnified film studies of the housefly. Smith had also made some notable early (1902) time-lapse films which he called, "The Birth of a Flower," "The Germination of Plants," and "Bud to Blossom." J. Stuart Blackton made the first animated cartoons for the motion picture in 1906; and in 1917, Max Fleischer introduced the first motion picture that combined actual photography with a cartoon character. Fleischer was also the first to attempt to eliminate the jerky motion in animated cartoons.

All the color processes used for the motion picture were originally derived from those developed earlier in still photography. The earliest process of motion picture color photography was called Kinemacolor and was developed by G. A. Smith and Charles Urban in 1906. This process was later supplanted by Technicolor and a process used by Gaumont. In 1935, a subtractive process known as Kodachrome was introduced. During this same year, a screen plate process called Dufaycolor was developed for amateur motion pictures. With the addition of color and sound to the film, the ideal of the motion pictures envisioned by Thomas A. Edison became a reality.

Three-dimension for wide screens constitutes another early technical development. Walt Disney's present-day Circarama and Raoul Grimoin-Sanson's 1897 Cineorama[23] (note the o) mark the limits of wide screen development.[24] Between these two processes, there lie an amazing number of attempts to change the size and shape of the screen. The most successful system is Cinerama, invented in 1938 by Fred Waller and developed during World War II as a gunnery training device. Cinerama provides a convincing sense of depth without the use of glasses. Three synchronized projectors with three separate filmstrips are required to fill the screen. CinemaScope and CinemaScope 55 (Twentieth Century Fox), VistaVision (Paramount), Todd-AO (MGM), Cinemiracle (Smith Dietrich Corporation), Superscope 235 (RKO Pictures), and Kinepanorama (Russian process similar to Cinerama and Cinemiracle) are other wide-screen systems which were developed to compete with Cinerama.[7] The Todd-AO system was the first to change the basic 35 mm film size; it uses double-width film and an aspect ratio of two to one. All the wide-screen systems use multiple sound tracks to create the illusion that sound is coming from the appropriate sector of the field of view.

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[23] When Cineorama was first publicly introduced at the 1900 Paris Exposition, an audience stood or sat in the basket of a simulated balloon; and as the balloon seemed to ascend, hand-colored motion pictures of the Riviera, Paris, Spain, England, and the Sahara were thrown on a circular wall some 333 feet in circumference by ten motion picture projectors. Grimoin-Sanson had locked ten 70 mm cameras together to take his panoramic views and had so precisely adjusted his cameras and projectors that the edges of the separate shots matched closely on the screen. Since each frame of the film was almost square, the pictures were more than 30 feet high! Thus, by 1900 two of the half cylinders of our contemporary Cinerama had been brought face to face and the ultimate in wide screen had been achieved. Cineorama, however, was only a three-day wonder because the police closed the show when it became a fire hazard. Kenneth MacGowan, "The Wide Screen of Yesterday and Tomorrow," _The Quarterly of Film, Radio and Television_, Vol. XI (Spring, 1957), No. 3, University of California Press, pp. 217-219.

[24] Circarama, first introduced at Disneyland and later at the 1958 Brussels World Fair, is small in comparison to Cineorama, but it has been spectacular. The audience walks under the lower edge of a circular screen and views a panoramic color film that takes them on an automobile ride throughout the United States. The screen, eight feet high and 130 feet in circumference, is divided into eleven panels. Eleven synchronized 16 mm projectors through openings in the strips, throw their films on the panels opposite.

Auditory Media

Many scientific and technical discoveries made in the fields of electricity and magnetism have set the landmarks in the development of such auditory media as phonograph records, radio, and magnetic recording.

The science of electronics rests upon the discoveries of Ampere, Oersted, Faraday, and Henry. It was these men who proclaimed the principles of electric induction by observing the electric and magnetic fields surrounding conductors carrying current. Joseph Henry observed in 1842 that the discharge of a Leyden Jar produced minute sparks between pieces of metal completely separated from the jar some distance away. The synthesis of this early knowledge led to a unified theory of the electromagnetic field by the Scottish physicist, James Clerk Maxwell, between the years of 1867 and 1873. This accomplishment is generally considered to have been one of the great inductive feats of the human mind.

The Maxwell equations showed that an electromagnetic wave is formed in the space surrounding a wire carrying an increasing or decreasing current. Maxwell also identified light waves as one form of electromagnetic radiation and predicted that other forms must exist. These experiments and conclusions were published by Maxwell in his

Electricity and Magnetism in 1873.

Radio. With the discovery of radio waves by Heinrich Hertz in 1886, an intensive period of experimentation began in both Europe and the United States. In 1895, Guglielmo Marconi transmitted a signal over a distance of a thousand feet across the Bolognese estate of his father. Subsequently, despite a number of conflicting claims, Marconi was officially credited with the invention of radio. At first, the Marconi "wireless" was confined to telegraphic code. Radio broadcasting as it is known today was later made possible by the technological contributions of Valdemar Poulsen, Lee DeForest, Sir John Fleming, I. Langmuir, and Reginald Fessenden.

Valdemar Poulsen, a Dutch engineer, in 1904, evolved the first wireless telephone. Lee DeForest, working with the vacuum tube earlier developed by Thomas A. Edison and Sir John Fleming, invented the three-electrode tube, or audion. This tube proved to be the cornerstone of modern radio and the other electronic devices which have since derived from it. Circuits for the audion were developed by the American Telephone and Telegraph Company, which acquired the DeForest patents. Also, long distance radio telephony was accomplished by this group in 1915. By 1916, DeForest was broadcasting from his High Bridge, New York station, the election returns of the Wilson-Hughes presidential campaign. This marked the beginning of modern radio.

FM Radio. For a number of years, radio engineers had known of the existence of ultrahigh-frequency wave lengths. By 1932, Major Edwin H. Armstrong, Professor of Electrical Engineering at Columbia University had applied for a patent on wide-band frequency modulation. In 1935, Armstrong constructed a frequency modulation transmitter and gave a demonstration of it before the meeting of the Institute of Radio Engineers. The following year, Armstrong asked the Federal Communications Commission to give him a construction permit to build his own FM station at Alpine, New Jersey. By the summer of 1938, the first FM station went on the air and the Federal Communications Commission was ready to assign the ultrahigh short-wave frequencies for general use.

Technically, the invention of FM meant staticless radio, a reduction of program fading, and increased tonal range. Particularly important is the selective nature of the FM receiver. When two FM stations are on the same frequency, the FM radio receiver selects the stronger of the two and eliminates the weaker one.

The Phonograph. The idea of a phonograph was an early dream of the human mind. According to one story, over three thousand years ago the Egyptians developed a device that produced the human voice. The first practical step taken that would lead to the phonograph was the invention of the Phonautograph by Leon Scott in 1857. When an operator spoke into the horn of his Phonautograph, the sound waves produced a back and forth movement of a parchment diaphragm and as the operator spoke into the horn, he simultaneously turned a cylinder covered with smoked paper by means of a crank. On this paper the bristle traced a visual wave pattern. This machine strikingly anticipated the Edison phonograph in its principal features, but it could not play back.

Even though various German experimenters had recorded sound on tin foil, the first practical phonograph was invented by Thomas Edison in 1877. Unlike the modern phonograph, it did not operate on electricity. The record was a sheet of tinfoil wrapped around a cylinder, which could be rotated. The first stylus of steel was placed in the center of a diaphragm which vibrated and traced a pattern on the foil when struck by sound waves.

The first improvement of the phonograph was to coat the cylinder with wax. On June 27, 1885, Chichester A. Bell, a cousin of Alexander Graham Bell, and Charles S. Tainter applied for a patent which provided for cardboard coated with wax in which the recording stylus engraved the pattern of its vibrations in narrow grooves. This patent also specified a disc record, but Bell and Tainter decided upon the cylinder as better suited to their purposes. Early in 1887, the Bell-Tainter cylinder machine was put on public view in Washington, D.C., and was named the "graphophone." The following year, Edison brought out an improved phonograph patterned after the Bell-Tainter principles. However, a new development succeeded in outpacing the cylinder phonograph in its prime. On September 26, 1887, Emile Berliner applied for a patent for a new type of phonograph which he called the "gramophone."[25] In this phonograph, Berliner first developed the method by which the needle vibrates sideways rather than up and down. He covered a disc of heavy plate glass with lampblack, set it revolving on a turntable in contact with a stylus on a feed screw so that it would create a spiral pattern on the disc. When actuated by sound waves, the stylus vibrated laterally and left a visual tracing on the lampblacked disc. Berliner fixed this delicate tracing with varnish and had the record photoengraved in metal. As Charles Cros, an amateur French scientist, had predicted to the Academy of Sciences in Paris in 1877, when this photoengraved record was played back through a stylus-and-diaphragm reproducer, the original sounds were recreated (30).

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[25] Today the terms "gramophone" and "phonograph" have become synonymous. They were not so in the nineteenth century. "Gramophone" then referred specifically to a talking machine employing lateral-cut discs, "phonograph" to a talking machine employing vertical-cut cylinders.

All the early models of phonographs were hand-driven and made use of ear tubes. Later came the spring-motor and horn models. During World War I, research brought forth the first workable microphones and amplifiers. Thereafter, the practical realization of electrical recording was open to anyone who cared to work on it, but surprisingly enough, very few availed themselves of this opportunity. In the United States, the initiative was assumed by the Bell Telephone Laboratories in the late fall of 1919. In 1925 the Orthophonic Victrola and the Electrola were placed on the market and eventually brought about a revolution in recording and playing techniques.

The first commercial electrical recordings were issued by Victor and Columbia in April, 1925. On September 17, 1931, RCA Victor demonstrated the first long-playing 33 1/3 rpm record, and in 1934, the phrase high fidelity first came into general use. In 1948, a new era for sound recording began with the introduction of LP or micro-groove recordings. These LP (long play) and EP (extended play) recordings represented a major technical improvement over the older type of disc recordings because they could provide better quality and make it possible to secure two to three times as many grooves to the inch. Also, rim-driven instead of axle-driven turntables made speeds under 78 rpm possible without excessive costs, and improved pick-up heads allowed exceedingly light needle pressure with consequent reduction in noise and wear. The development of stereo discs in late 1957 gave disc recordings an additional new fidelity. Other improvements in fidelity and dynamic range have come with the refinement of electronic and mechanical components.

Magnetic Recording. There is no definite date marking the beginning of magnetic recording. Valdemar Poulsen, a Danish physicist, applied for the first patent of a workable magnetic wire recorder known as the Telegraphone on December 1, 1898, but there are indications that experimenters before him had thought about the possibility of recording sound magnetically.[26] Poulsen's Telegraphone was exhibited at the 1900 Paris Exposition where it created a sensational interest in all who saw and heard it, but it remained to be practically forgotten until the thirties.[27] Meanwhile, Poulsen and his chief engineer, P. O. Pedersen, investigated many of the possibilities of magnetic recording. They, together or separately, patented methods of recording perpendicularly as well as longitudinally and invented methods of electroplating magnetic materials and magnetic heads.

In 1921, W. L. Carlson and G. W. Carpenter applied for a patent on alternating-current bias which led the way to the practically noiseless, undistorted magnetic recording of today. A few years later in 1927, J. A. O'Neill received the first patent in the United States for a tape with a coating. In 1936, in Germany, The Allgemeine Electricitats Gesellschaft (AEF) and I. G. Farben merged their magnetic recording interests in the new Magnetophon Company and produced a recorder that used a film coated with iron powder. Although the coated tape did not at first perform as well as steel tape, the chemists of I. G. Farben finally succeeded in the late thirties in making a coated tape which proved to be superior to other types. In 1940, Doctors H. J. von Braunmuhl and W. Weber of the German Rundfunk (Radio Network) observed while experimenting with a Magnetophon that the use of ac bias resulted in considerably less noise and much better fidelity.[28] Their improved Magnetophon, which employed ac bias and coated tape, became the prototype of some of the best of our modern tape recorders. It is strange to note that the development of wire recording was given an impetus in the United States during the same period in which the Magnetophon was being improved in Germany. After World War II, reports of its excellence and demonstrations of the Magnetophon brought the recognition that wire could not give comparable fidelity at equivalent speeds.

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[26] A reference to the idea of recording sound magentically can be found in The Electrical World of September 8, 1888, by Oberlin Smith.

[27] In 1903, the American Telegraphone Company was formed at Springfield, Massachusetts, to manufacture the Poulsen telegraphone, but it went into receivership and discontinued its operations after a few years because conditions were not yet ripe for the general acceptance of magnetic recording.

One of the first attempts to synchronize magnetically recorded sound with motion pictures was made in Elstree, England, in 1929. Louis Blattner, a motion-picture producer, made use of what he called the "Blattnerphone," an adaptation of Dr. Kurt Stille's solid-steel-tape recorders. Despite this achievement, magnetic recording did not take hold because direct-current bias recording was too noisy; the steel tape reels were awkward to use because of their size; and synchronization of sound and picture was difficult because of the high speeds at which the tape had to move in order to achieve good sound quality. Interest in the use of magnetic recording for motion-picture sound was renewed after World War II when the German achievements in magnetic recording became known.

During World War II, Marvin Camras at the Armour Research Foundation in Chicago had perfected a method of using supersonic bias in recording on wire; also, developmental work by Holmes and Clark (of Stromberg-Carlson), by Bell Laboratories, by Brush Electronics

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[28] The Braunmuhl-Weber patent was published in the United States in 1943 as a "Method of Magnetic Sound Recording." A copy of a letter in which Doctors Braunmuhl and Weber describe how they discovered the superiority of ac bias is quoted in Joel Tall, Techniques of Magnetic Recording (New York: The Macmillan Co., 1950), pp. 18-21.

Company, by Heller Magnograph Company, and by many others had given an impetus to magnetic recording on film in the United States. Since 1948, when the first commercial film recorder adapted to use magnetically coated film was demonstrated at the convention of the Society of Motion Picture and Television Engineers in Santa Monica, improvements in the application of magnetic recording to motion-picture production have steadily emerged.

An outstanding technical development in magnetic recording in recent years has been video tape recording or the recording of scenes on magnetic tape. Dr. Kurt Stille of Germany had been reported working on this problem as early as 1929. However, it was not until 1952 that a practical video tape recorder was demonstrated in the laboratories of the Bing Crosby Enterprises, Incorporated, in Beverly Hills, California, by John T. Mullin and Wayne R. Johnson. About one year later, RCA researchers headed by Dr. Harry F. Olson demonstrated video tape recording, both in black-and-white and in color, at the RCA Laboratories in Princeton, New Jersey. In April, 1956, the Ampex Corporation demonstrated their video recorder to broadcasters in Chicago.

Neither the Crosby nor the RCA video tape recorders met the requirements of television broadcasters. The Ampex recorder is now most commonly used in television broadcasting because it circumvented the problem of high speed tape in an ingenious manner. Information is recorded upon a magnetic tape 2 inches wide as it moves at only 15 inches per second. Instead of a single stationary recording head, the head assembly of the Ampex machine consists of four recording heads that are mounted on a rotating drum; this drum revolves at high speed across the width of the tape. During recording or reproduction one or another of the heads is in contact with the surface of the tape.

At the moment when one head is leaving one tape edge, another head is engaging the other tape edge; both heads are in physical contact with the tape for an instant while the recording or reproduction function is electronically transferred from one head to another.

The videotape recorder has been used for military purposes, for recording television programs for delayed transmission, and for motion-picture production. However, the perfected videotape recorder shall undoubtedly find increasing applications in industry and education. The ultimate development of a low-cost, relatively simple videotape recorder which could make it economically feasible and easy to operate could extend its uses even more widely.[29]

The Microphone. The parent of the microphone was the telephone receiver invented by Alexander Graham Bell in 1876. The term microphone, however, was first used by D. E. Hughes in connection with his discovery in 1878 that a loose contact in a circuit containing a battery and a telephone receiver may give rise to sounds in the telephone corresponding to the vibrations to which the contact is subject. Hughes constructed his microphone in the form of a horizontal carbon rod resting in grooves in two carbon blocks with the battery and telephone receiver being connected in a series with these blocks. Microphones have since developed along two principal lines. First, there have been instruments similar to the Hughes type; second, there have been instruments in which the electrical energy is mainly derived through the microphone from the mechanical energy of the sound waves.

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[29] By the use of television cameras and videotape recorders, motion-picture production costs can be cut considerably. Two or more scenes can be mixed electronically during recording; scenes can be reviewed immediately after a recording is finished, complete with sound. Cutting can be simplified because the picture and sound are automatically synchronized during recording. Editing is also simplified because picture and sound can both be edited by cutting across the tape at approximately a 90 degree angle.

Facsimile

Alexander Bain first used a wire circuit to mark paper in 1842. He can be called the father of facsimile because his electrochemical recording telegraph established the primary elements of modern facsimile apparatus.

Since the development of facsimile broadcasting, many technical developments have been made. The color fax system, which sends colored pictures by radio facsimile, was first demonstrated experimentally in 1947. The following year, ultrafax, which can deliver printed messages with the speed of light, was demonstrated by the Library of Congress. Multi-plexing has made it possible for FM aural programs and facsimile to be transmitted simultaneously over the same assigned wave length.

Television

Like many inventions, television is the product of the insights and discoveries of many men through the ages. Even though there is some doubt about where television began and who first coined the word, there is no lack of evidence that television owes much to the important technical contributions made in electricity and radio.

Invention. The first significant event in television occurred in 1873 when it was observed that crystalline selenium was photoelectric. Two years later, C. R. Carey of Boston designed the first television system. In 1875, John Kerr discovered the Kerr Effect. Simultaneously, television systems were being designed by Sawyer, Senlecq, de Paiva, and Leblanc.

Most scientists begin their history of television with Paul Nipkow. Nipkow, a German, patented the television scanning disc used in later mechanical video systems in 1884. He did not rely on electronic devices because they were unknown in his day. Instead, he used a revolving disc placed between a powerful source of light and the subject. A spiral row of holes was punched in the disc which permitted light to reach the subject. The light was so arranged that only the light passing through one of the holes at a time could shine on the subject. As the spiral holes revolved, light from the first hole would pass across the top from the second hole and on across the other holes. When the disc had made one complete revolution, the subject had been completely "scanned."

In 1889, L. Weiller, in Europe, devised a system of scanning in which the place of the Nipkow disc was taken by a rotating drum on which a number of mirrors were tilted at different angles. As the drum rotated, the image was scanned in a series of lines and projected on to a selenium cell for conversion of light into electricity. In later years, the mirror drum was greatly improved and often used in early television apparatus. Even though Weiller is given credit for the mirror drum by reason of publication, L. B. Atkinson of England really designed the first one in 1882.

The next important development in television came at the end of the nineteenth century when Karl Braun made his Braun cathode ray tube. A. R. B. Wehnelt further improved it in 1904, and in 1907 Rosing designed a way in which it might be used to reproduce pictures. Another progressive step in the advancement of electronics was made when Albert Einstein announced his theory of the photoelectric effect in 1905. This theory was to become the fundamental principle of the modern television camera. Two years later, Campbell-Swinton worked out in considerable detail an electronic method television that could be accomplished by the use of two cathode ray tubes. In this plan, Campbell-Swinton almost completely anticipated modern television.

However, before television could realize its potential development, the mechanical method of scanning had to be replaced if satisfactory pictures were desired. Most of the inventive efforts during the twenties were directed at improving the mechanical discs. By 1929, mechanical discs were producing a picture with ninety lines. Nevertheless, this achievement was more or less nullified because the images obtained were blurred and flickering. As a result, the physical limitations of the mechanical process hampered the progress of television until it was supplanted by the electronic method.

Electronic Television. It was obvious that the mechanical method of scanning had to be replaced if satisfactory television reception was to be achieved. It remained, therefore, for Vladimir Zworykin to revolutionize television by his development of an all-electronic television receiver which he called the Kinescope. In 1933, when Zworykin developed a completely electronic camera which he called the iconoscope, the electronic barrier was crossed and modern television had come of age.

In spite of the inventions of Zworykin, such men as Charles Francis Jenkins of Washington, D.C., and John L. Baird in England, used scanning discs connected to modern vacuum tube amplifiers and photoelectric cells as early as 1925. Also, Philo T. Farnsworth, a California scientist, invented a new kind of cathode ray television receiver and an image dissector camera in 1928.

Experimental Telecasts. One of the first practical commercial television demonstrations occurred in 1923 when C. F. Jenkins sent a picture of President Harding from Washington, D.C., to Philadelphia by television. A year later, Jenkins made the first transmission of motion pictures using motion picture film. The first demonstration of real television is generally considered to be that given by J. L. Baird of London on January 27, 1926. Two years later, Baird sent the first television picture from England to America. In June of 1928, he took the first outdoor television pictures, using sunlight for illumination. In 1926 the Jenkins Laboratory of Washington, D.C., arranged the telecasting of the first television weather map.

Meanwhile, the American Telephone and Telegraph Company demonstrated the transmission of television over an ordinary long-distance telephone line between Washington, D.C., and New York City, and over a wireless circuit between Whippany, New York, and New York, New York. In 1928, WGY in Schenectady, New York, became the pioneer television station in the United States. During this, RCA also established an experimental television station with the call letters W2XBS. In 1931 E. F. W. Alexanderson of General Electric Company sent a rectangular design from Schenectady to Australia and back again in about an eighth of a second.

Color Television. It was realized quite early that greater realism could be conveyed to the television screen if the images could be reproduced in natural color. John L. Baird of England and the Bell Laboratories' scientists first achieved color television in 1928 and 1929 respectively. To reproduce all the colors of a scene, three separate pictures are required, each showing one of the fundamental colors of red, green, and blue. In the 1929 methods, three complete transmission systems were used. Properly colored filters picked out the colors desired. One system transmitted the reds, another the greens and the third, the blues of the original. At the receiver, each picture was reproduced in the corresponding colors. With an arrangement of mirrors which partly reflected and partly transmitted light from the other side, the three were recombined, and the viewer saw them fused into one picture. These systems were, however, unsuitable for regular telecasting.

On August 29, 1940, the first practical system of color television was announced by the Columbia Broadcasting System. Its engineer, Peter Goldmark, had invented a system based on experiments conducted by Isaac Newton in 1666, and the principles of the first commercially successful Kinemacolor process. On June 1, 1941, daily color transmissions over WCBS-TV, New York, were begun for a field test period. On October 10, 1945, the Columbia Broadcasting System demonstrated ultrahigh-frequency color telecasting. The National Broadcasting Company had made the first color telecast by mechanical means from a television receiver on February 20, 1941.

Teaching Machines

By the middle fifties, there came to be a widespread interest and activity in teaching machines or self-instructional devices. A variety of complex, efficient machines and teaching machine programs were developed in schools and colleges throughout the country, research studies were launched, regional and national conferences on teaching machines and programed learning were organized, and a new abundance of unpublished and published documents on automated learning and teaching came into existence.

Definition and Function. According to one definition, "the teaching machine is a mechanical or electro-mechanical device to present programed material to the student, and, to perform as an instructor directing and processing information by establishing a closed-loop between the student and the machine." Lumsdaine has stated that "all the devices that are currently called teaching machines represent some form of teaching" whereby the individual student is presented "with programs of questions and answers, problems to be solved, or exercises to be performed." In each instance, teaching machines always incorporate some type of feedback so that the student may be instantaneously informed of his progress as he proceeds from step to step.

Lumsdaine lists three important ways in which teaching machines differ from other types of audio-visual materials:

> First, continuous active student response is required, providing explicit practice and testing of each step of what is to be learned.
>
> Second, a basis is provided for informing the student with minimal delay whether each response he makes is correct, leading him directly or indirectly to correction of his error.
>
> Third, the student proceeds on an individual basis at his own rate--faster students romping through an instructional sequence very rapidly, slower students being tutored as slowly as necessary, with indefinite patience to meet their special needs. (52)

Teaching machines have been classified into three categories: stimulus, response, and stimulus-response. At a symposium on "The Automation of Teaching" held in August, 1958, at a meeting of the American Psychological Association, the functions of teaching machines in the instructional process were said to include: (a) memory or storage of content, problems, tasks, and the like that constitute the goal of the instructional device; (b) control, sequence programer or organization of content for presentation; (c) presentation, or means of indicating the particular element of content or task on which the subject is to work; (d) performance acceptor, or provision for obtaining a record of student activity; (e) performance decoder, or evaluator, interpreting what the student has done; (f) performance memory, or record of student performance (16).

The function of the teaching machine or what the teaching-machine programer should be trying to do according to Lumsdaine is to automate "a tutorial process of individual student-teacher interaction" rather than a mass communication process. Consequently, if a teaching-machine system is conceived as an automated individual tutor, the crucial problem of automated self-instruction lies in the programing of individual instruction. The program or curriculum material or subject matter that is placed in the machine must be prepared in such a manner so that each succeeding step builds on what has gone before.

First Teaching Machines. Antecedents of the modern teaching machine can be found in children's toys, educational games, and various apparatus and mechanical devices developed more than a century ago. Mellan uncovered the earliest record in the United States Patent Office as that of H. Chard, dated February 16, 1809, which described a "Mode of Teaching to Read." S. Randall acquired patents dated October 1, 1810, and January 11, 1812, on a "Mode of Teaching to Write." Probably, the first systematic attempt to integrate a theory of learning in a mechanism was made by Mme. Maria Montessori in 1914. She believed that there should be exercises that aided the child in his normal growth and development, in walking, breathing, and talking. One of these exercises consisted of a series of blocks of wood with ten holes of different diameters bored into it and ten little wooden cylinders just fitting the holes. Since a child could not put a cylinder in a hole too small for it, or into a hole too large without having a cylinder left at the end of the exercise, the materials automatically informed him of his errors.

Pressey's Self-Instructional Test-Scoring Devices. Teaching machines and the instructional programs used in them developed to a large extent as the result of experimental studies by learning psychologists. In 1926, Sidney L. Pressey of Ohio State University saw the possibility of using a mechanical device for administering and scoring tests. Consequently, in the late twenties and early thirties, Pressey and his students developed almost a dozen devices which exposed multiple-choice questions to students.

Pressey commented in 1932 as follows:

> The writer regards the entire field touched upon in these studies as still almost wholly unexplored . . . Fanciful though some of this may seem, there is good evidence to suggest the possibility of each one of these things. The problems of invention are relatively simple; with a little money and engineering resource, a great deal could be done. The writer has found from bitter experience that one person alone can accomplish relatively little, and he is regretfully dropping further work on these problems. But he hopes that enough may have been done to stimulate other workers, that this fascinating field may be rapidly developed. (73)

Regardless of Pressey's enthusiastic assessment of the teaching machine, no further work seems to have been done until the advent of World War II. It was at this time that the term training device first was used and when the automation of instruction had its greatest development and use thus far.

Contributions of Skinner. In a 1954 paper titled, "The Science of Learning and the Art of Teaching," B. F. Skinner of Harvard first proposed that his extensive experimental work on behavior had direct implications for teaching and could be implemented by appropriate mechanical devices. Skinner's first teaching machine was similar to Pressey's. Designed for use with young children, it presented a question and a series of slides with numbers or letters which could be used in the machine to form a correct answer. Skinner's machine was different from Pressey's because it was designed to teach rather than test students. The object was to reinforce correct answers rather than to determine whether or not a child knew the correct answers.

Skinner developed about five different types of teaching machines, but his chief contribution to the teaching machine development was in the programing of content for shaping responses. Programing is the crucial problem in the effective educational use of teaching machines. Skinner comments on the difficulty of programing as follows:

> It is not easy to construct . . . a program. Where a confusing or elliptical passage in a textbook is forgivable because it can be clarified by the teacher, machine material must be self-contained and wholly adequate. There are other reasons why textbooks, lecture outlines, and film scripts are of little help in preparing a program. They are usually not logical or developmental arrangements of material but strategems which the authors have found successful under existing classroom conditions. The examples they give are more often chosen to hold the student's interest than to clarify terms and principles. In composing material for the machine, the programer may go directly to the point. (91)

Military Contributions. Much of the work of the military has centered upon training devices rather than upon individual self-instructional techniques of presenting subject matter. Applications during World War II were concerned primarily with the development of perceptual-motor skills. Training devices were constructed which simulated actual equipment so that correct operations could be mastered and so that trouble-shooting skills could be attained. In the postwar period, when equipment became more complex, training devices for teaching problem-solving skills were developed.

Contributions from Other Sources. Finn (17, 18, 19, 20, 21), Pask (52), Ramo (76) and others have made significant theoretical contributions to the developing concept of instructional technology. Also, a number of symposia on instructional technology have been held by the National Academy of Sciences, the Office of Naval Research, the Department of Defense, and the Air Force.

Aside from the teaching potential of teaching machines, their contribution to educational research promises to effect the organization of content as well as the methods of teacher education. For example, teaching machines now make it possible to determine in a relatively short period of time the comparative effectiveness of various methods for a given content, the organization of content for optimal learning, and the organization of learning in terms of a wide variety of instructional materials.

Teaching machines also make it possible to apply operation game methods to education. It would be entirely possible to give student teachers and future school administrators several years' experience in decision making during the period of one semester. Operational game methods in teacher education might also involve the presentation of various forms of content designed for specific levels of student capacity and then providing a mechanical means whereby the student could vary the different portions of the teaching plan and evaluate the results. Machines could also be employed to make problem-solving studies as well as to aid in the development of educational theory.

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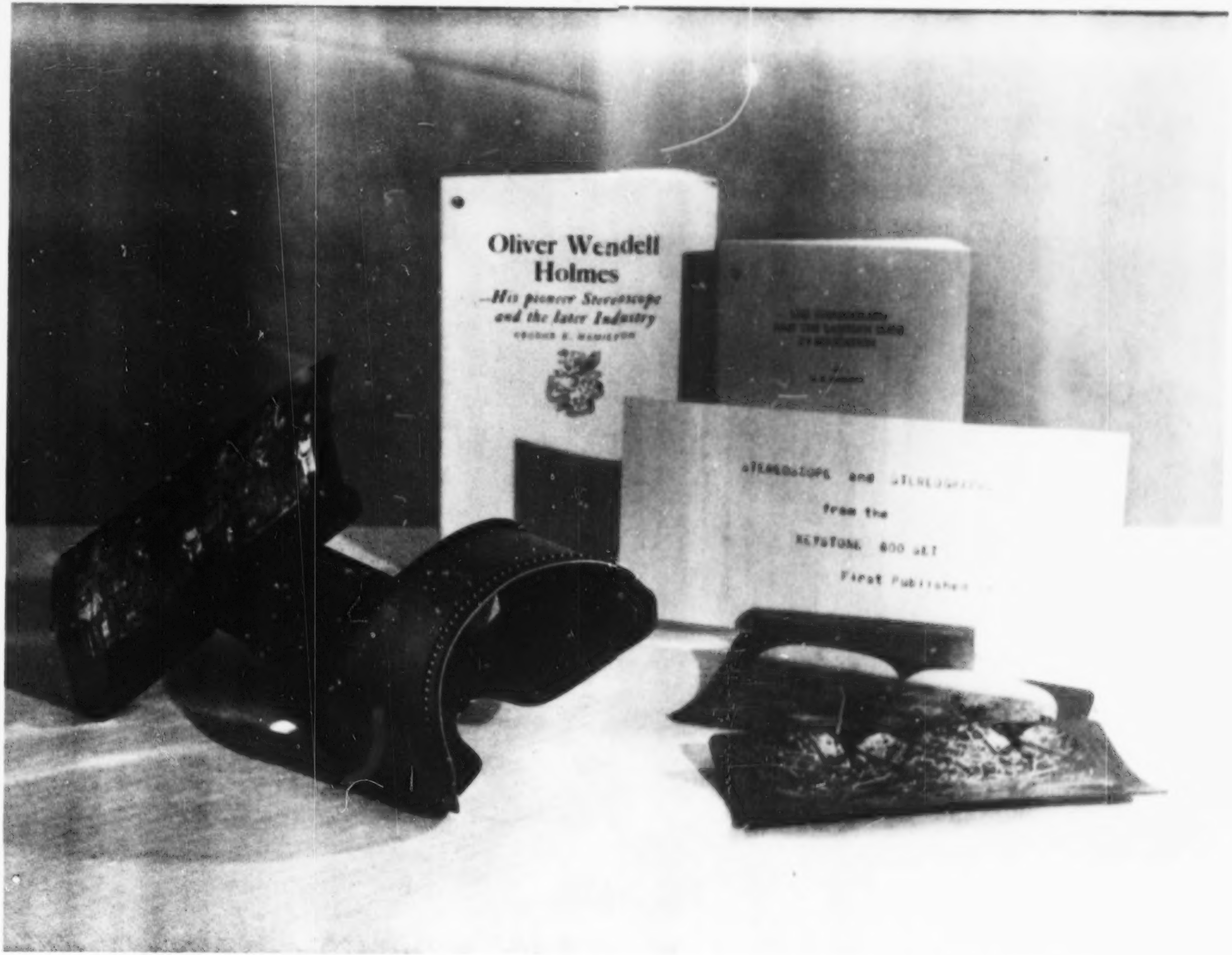
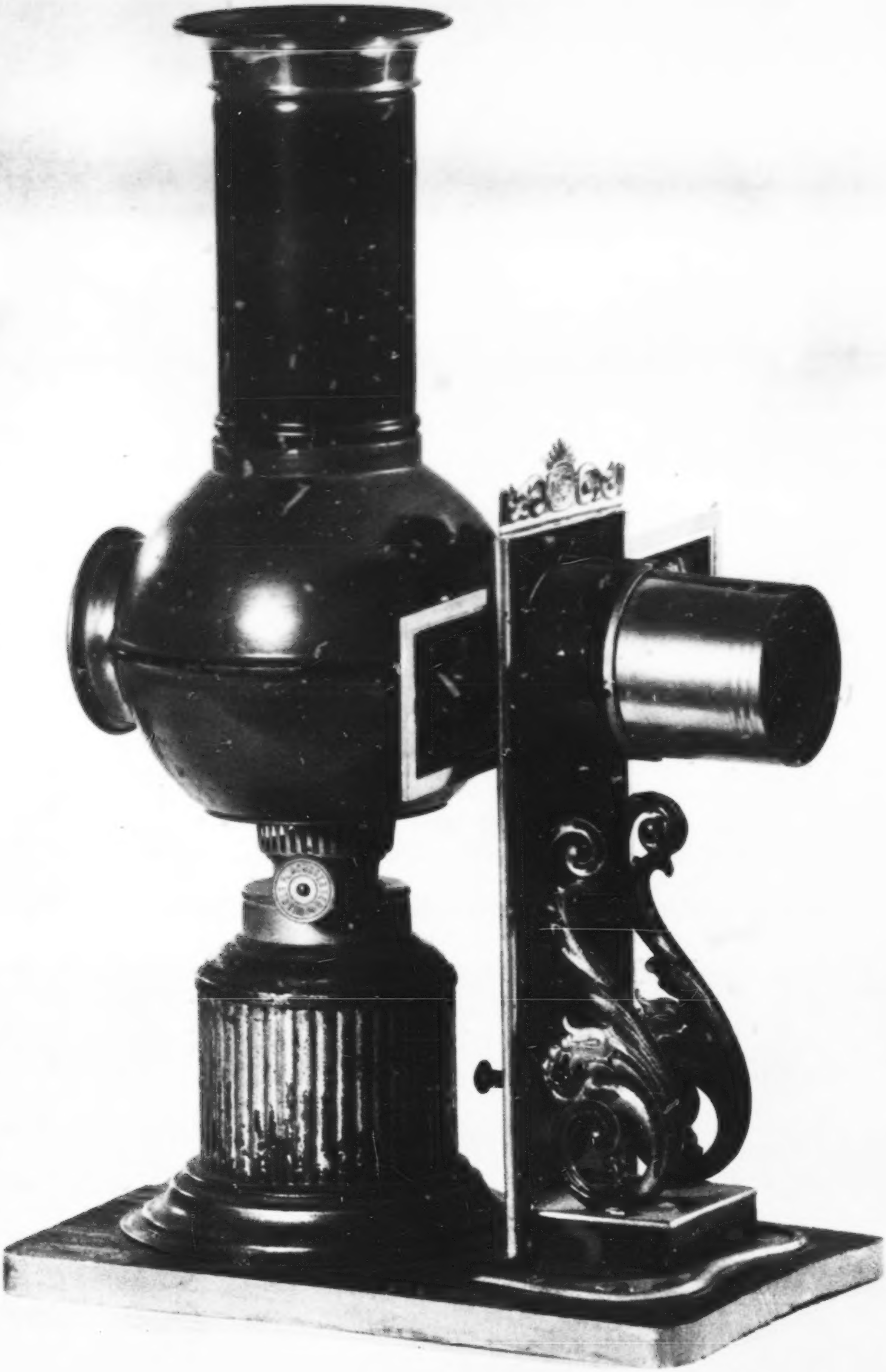
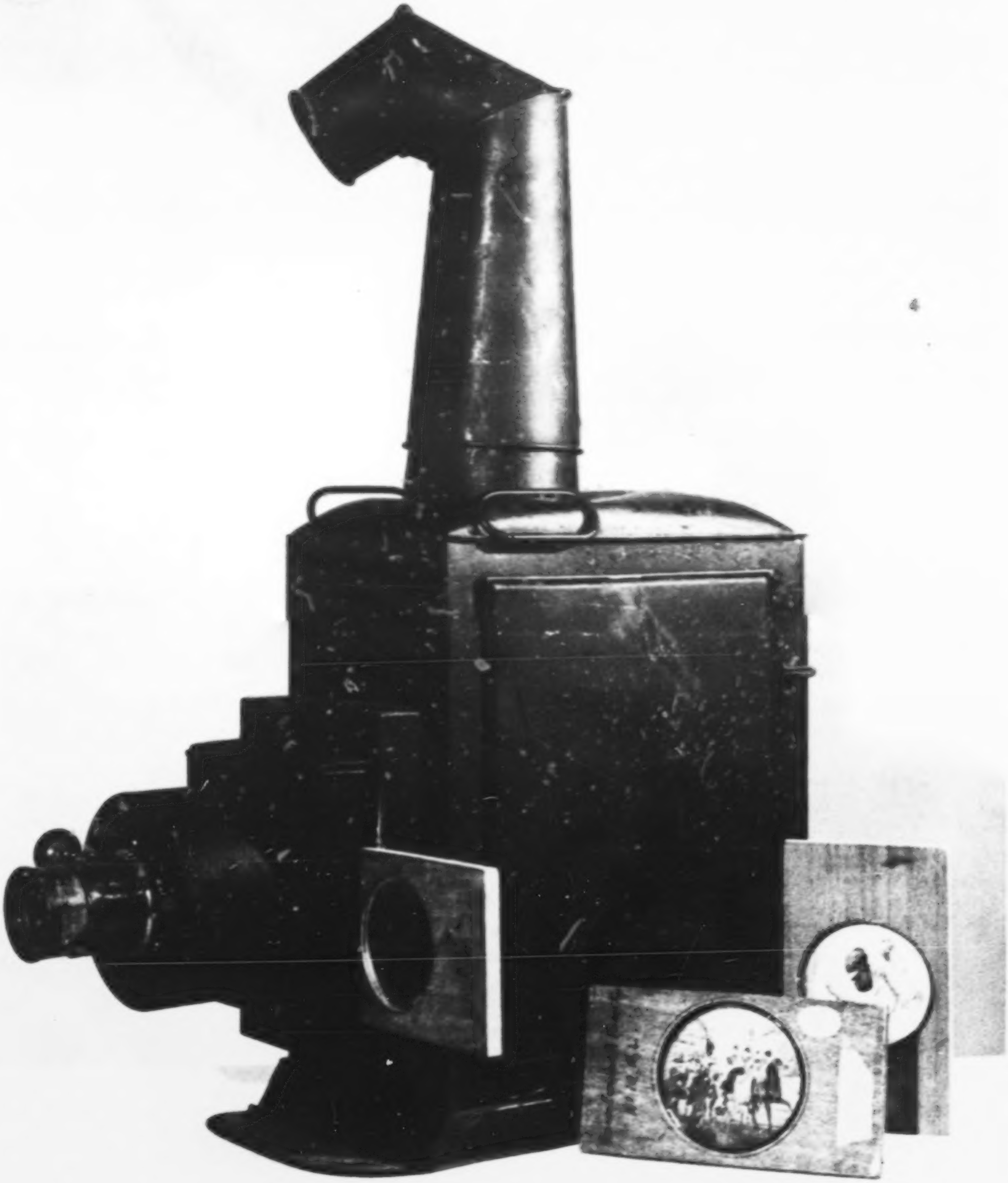
ILLUSTRATIONS

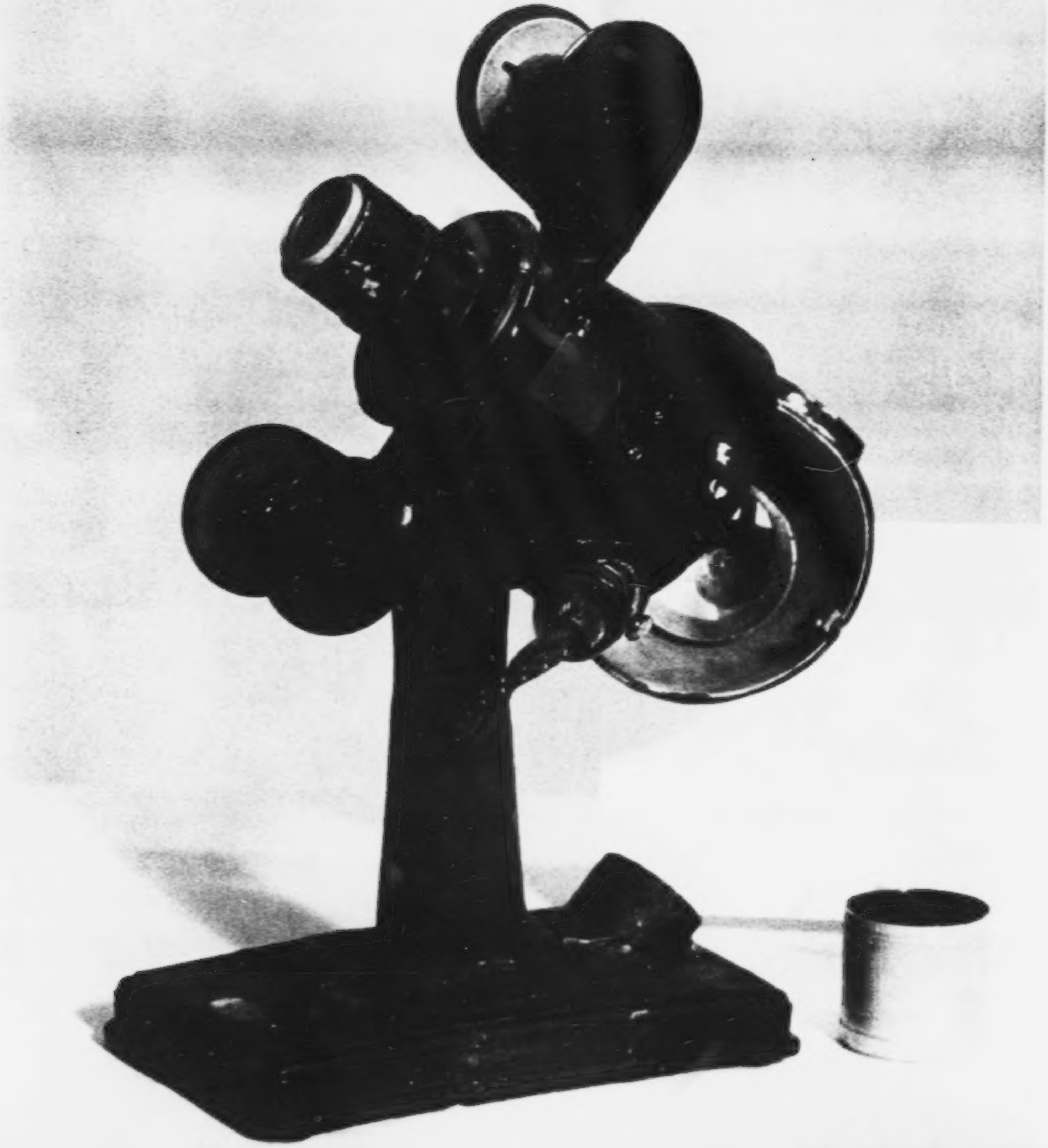

Oliver Wendell Holmes
—His pioneer Stereoscope and the later Industry
from the
KEYSTONE 600 SET
First Published



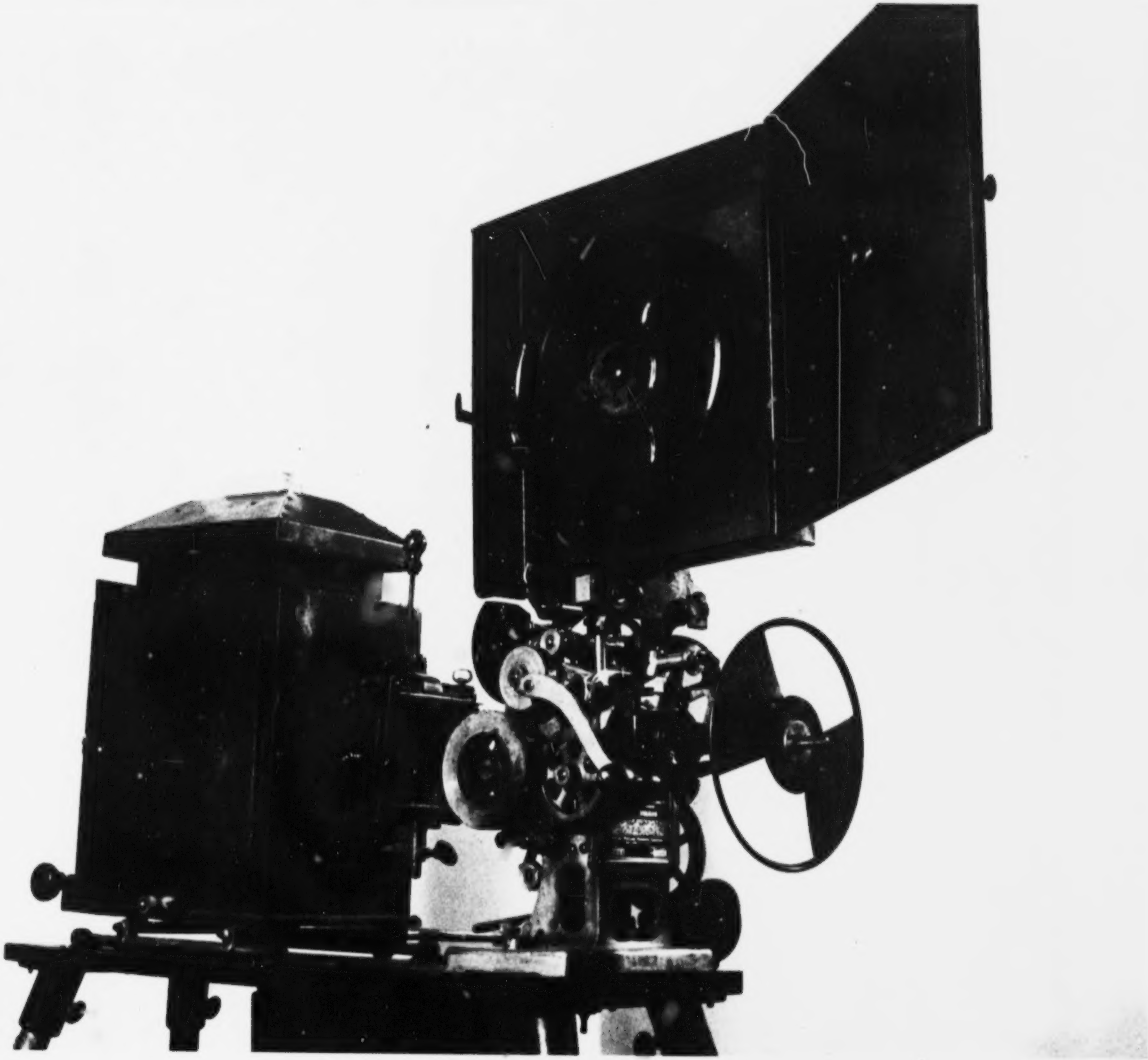
Kerosene Slide Projector (1876).



LIMELIGHT slide projector. Hand painted slides, approximately 6" in diameter, permanently mounted in wood frames.

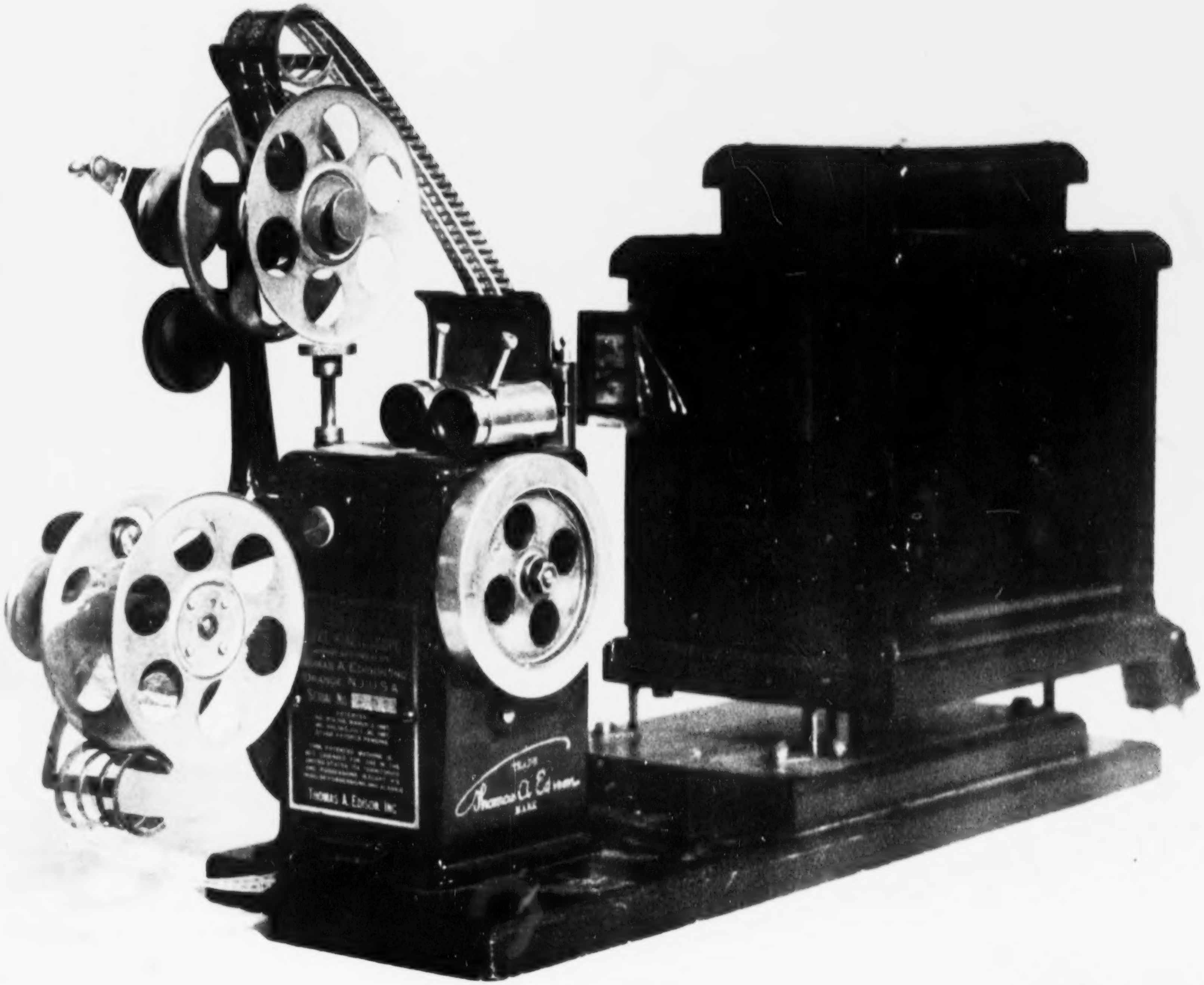


BRAYCO, first filmstrip projector, invented by J. R. Bray.

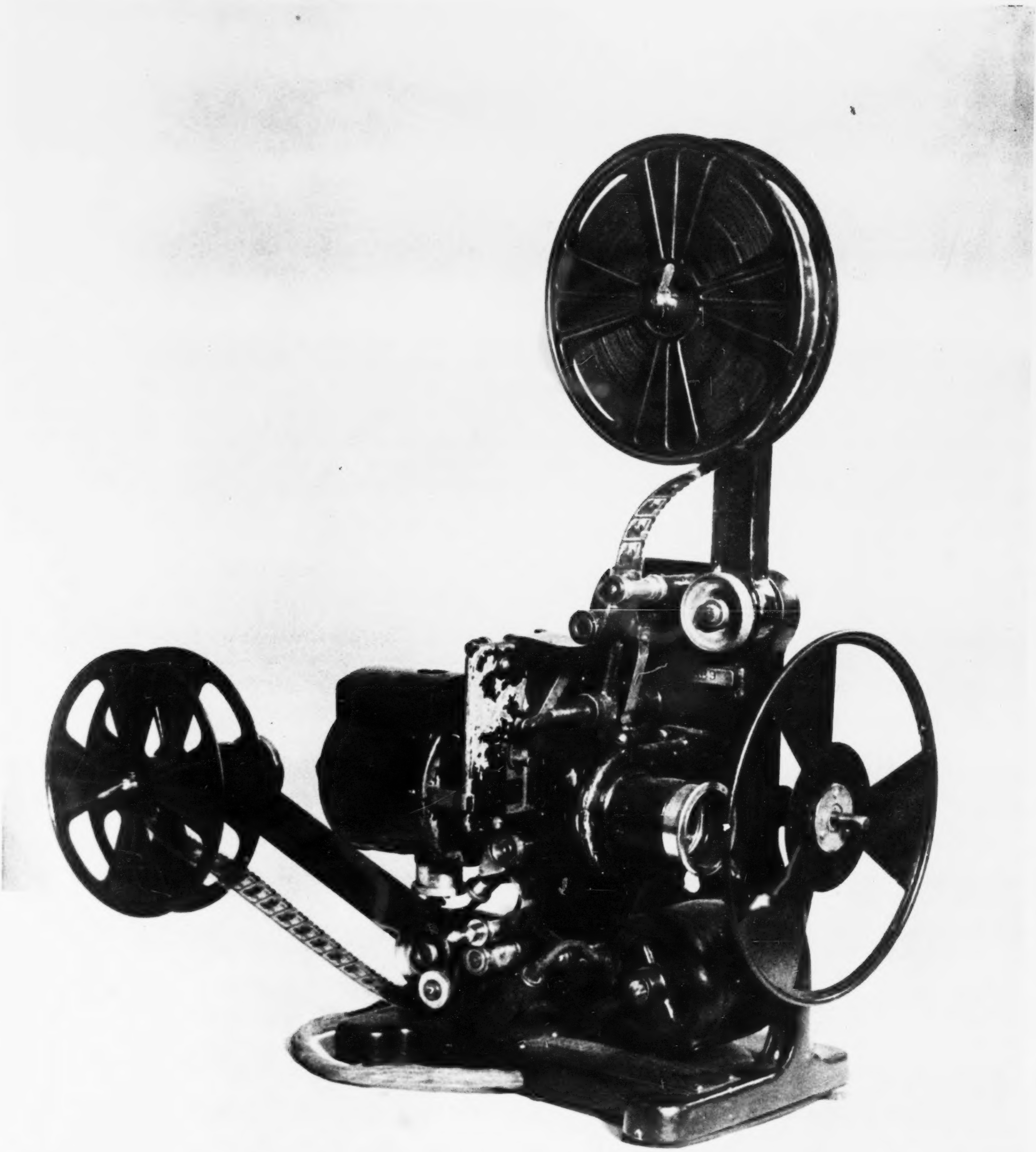


POWERS 35 mm, hand-cranked, arc, 35 mm motion picture projector, Pat. 1904, 1906. Serial 9851.

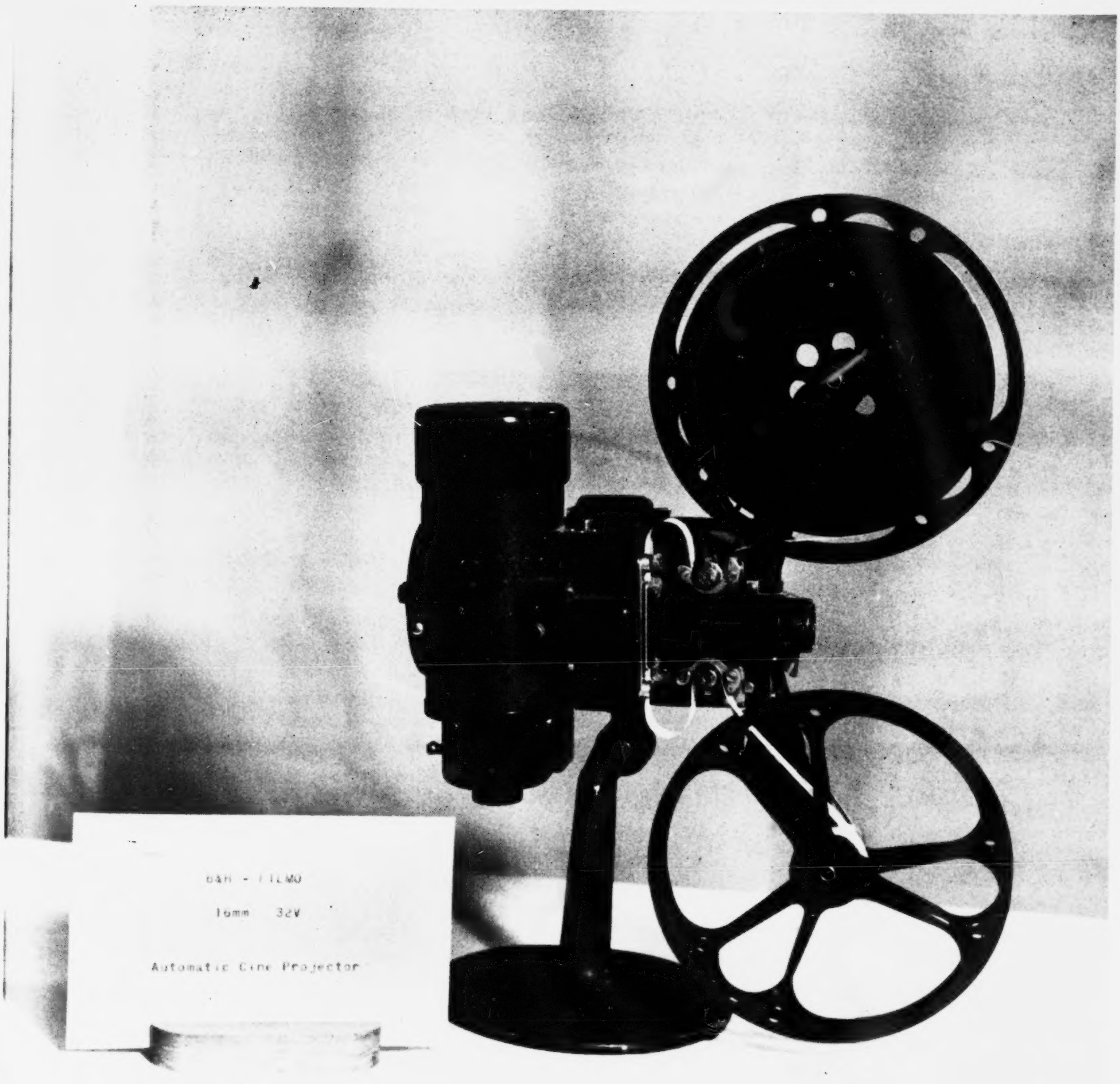
VI


Trade Thomas A. Edison Mark
THOMAS A. EDISON, INC.

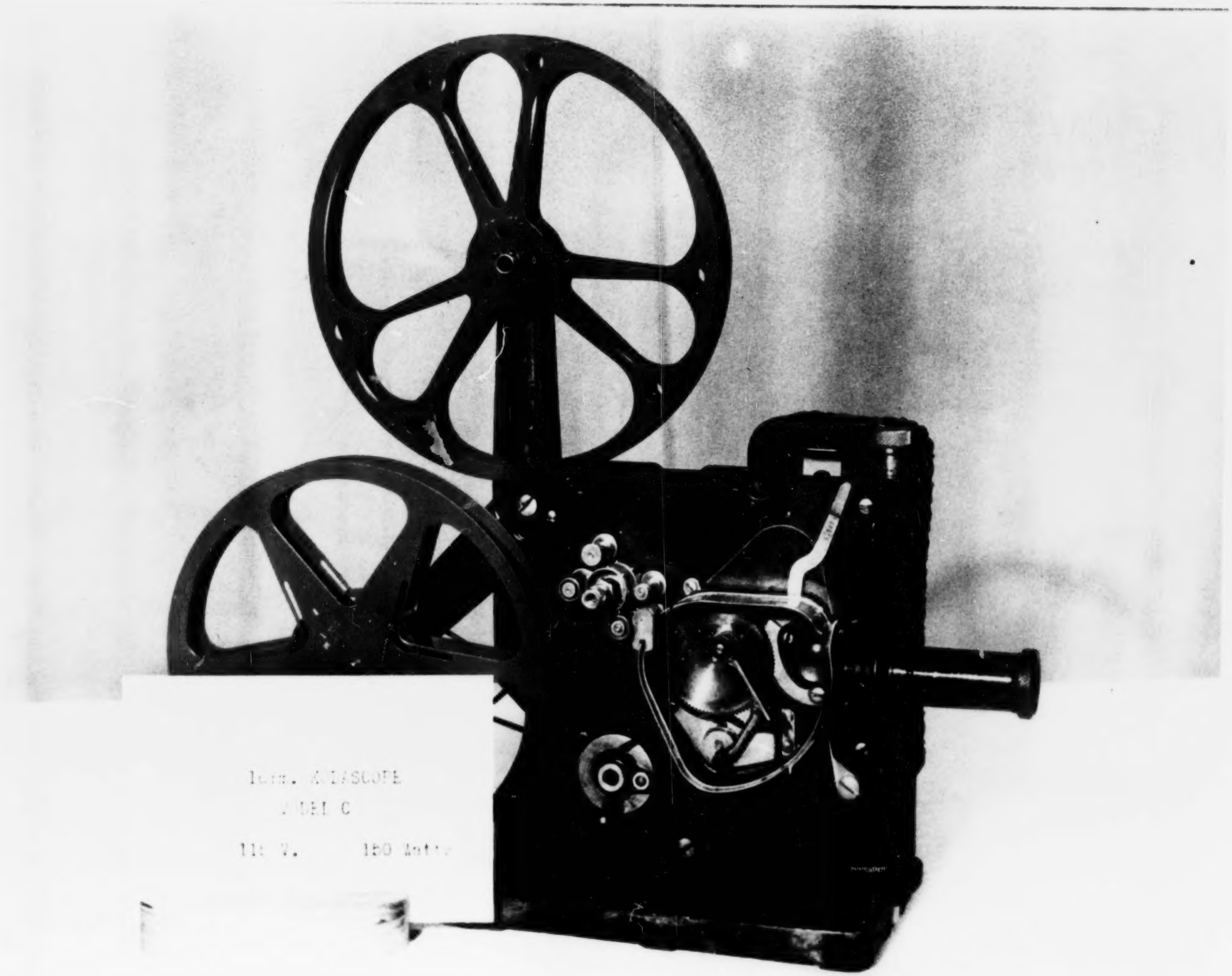
EDISON KINETOSCOPE. See also A-7-8-9. Shows the three rows of pictures clearly; also two projection lenses (one for the slide shown in place; it was cracked in shipment).



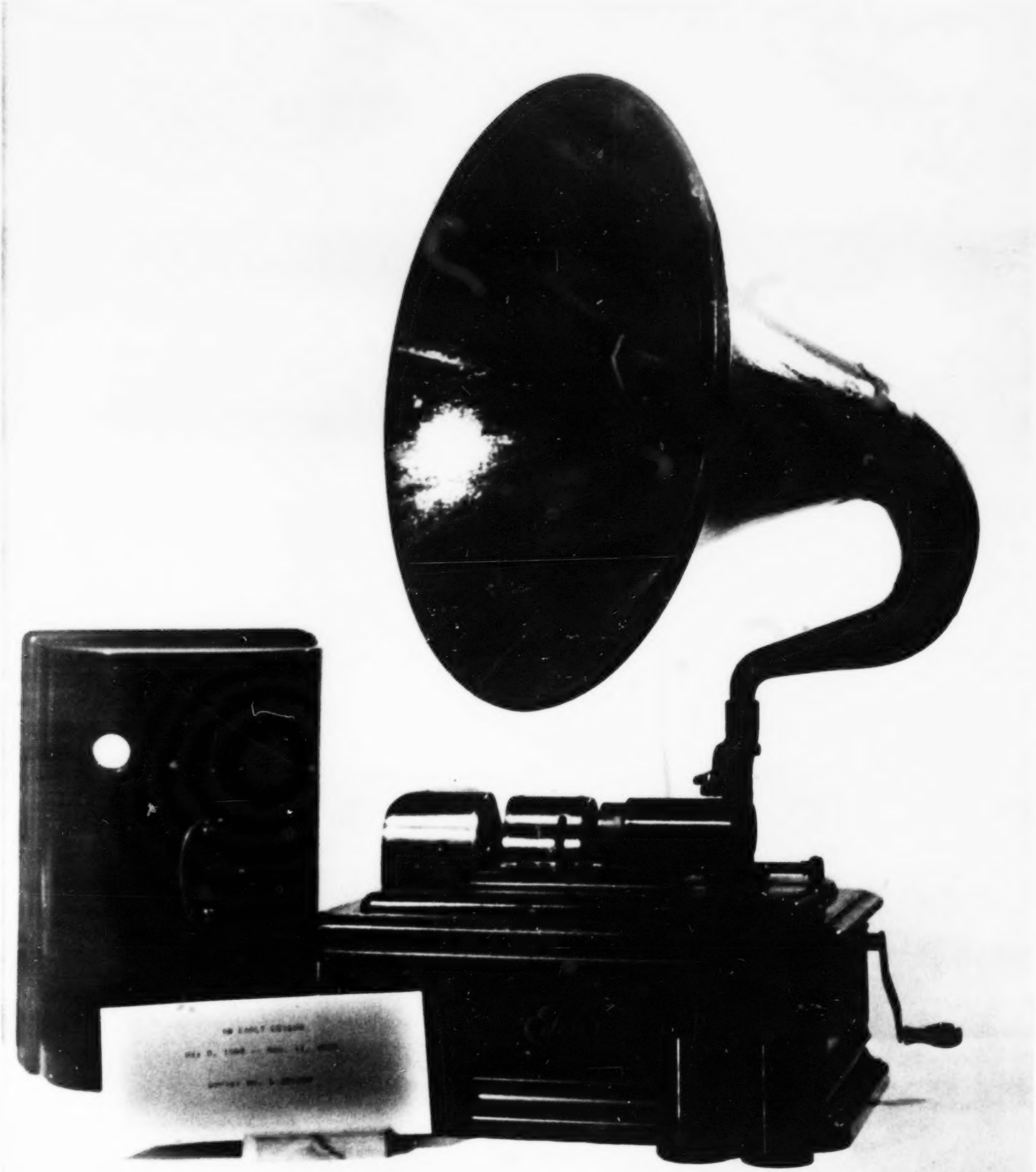
PATHESCOPE "New Premier" 28 mm projector, the first widely used safety projector for classroom use without booth. Imported from France then made here 1912-14 and later.


B&H - FILMO
16mm 32V
Automatic Cine Projector

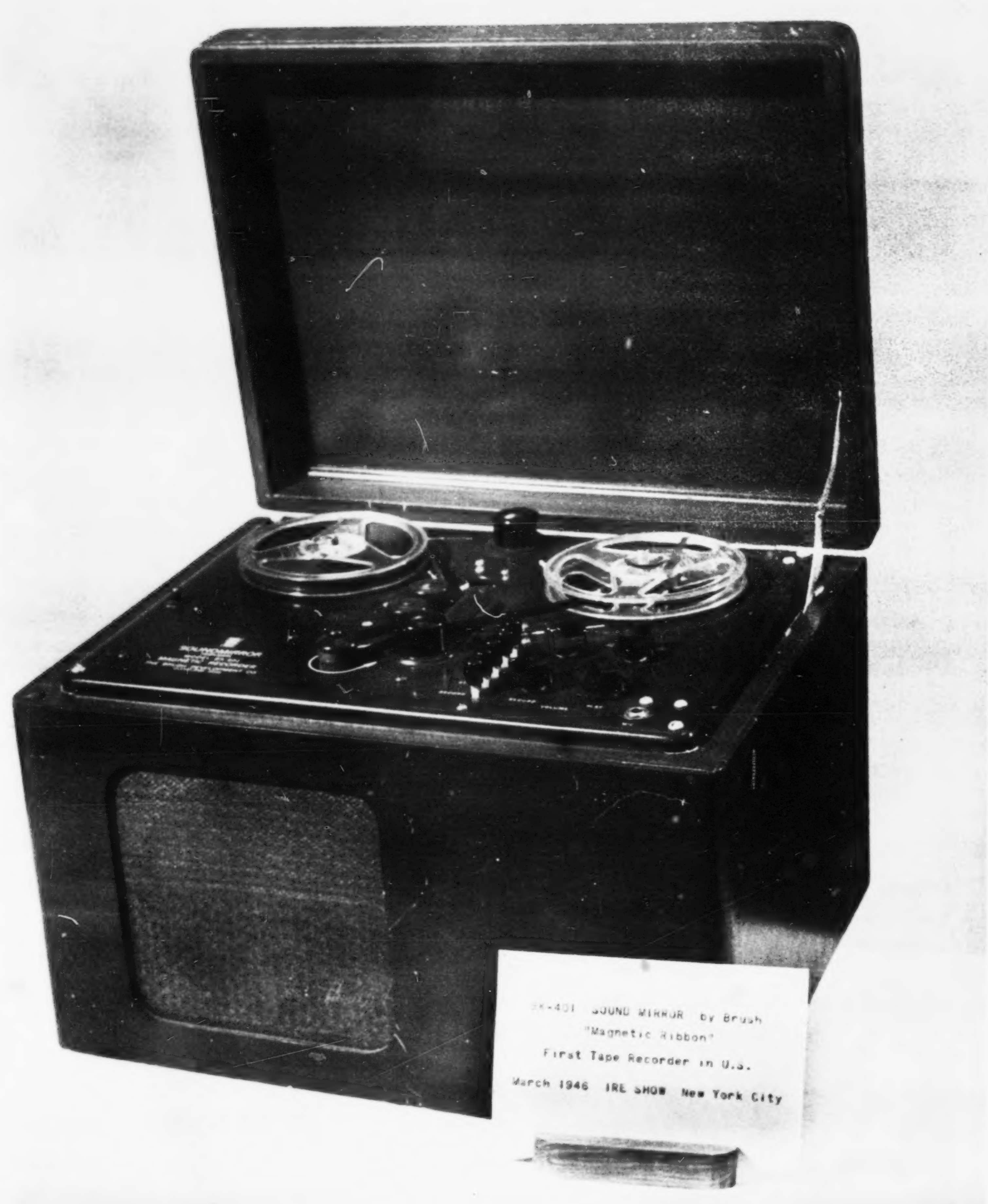
BELL & HOWELL "FILMO" 16mm silent motion picture projector. This is a special model designed to operate on 32-volt direct current in the many then existing locations where utilities power was not available. Regular models ran on 110-12-v. A. C.


16mm. KODASCOPE
MODEL C
115 V. 150 Watts

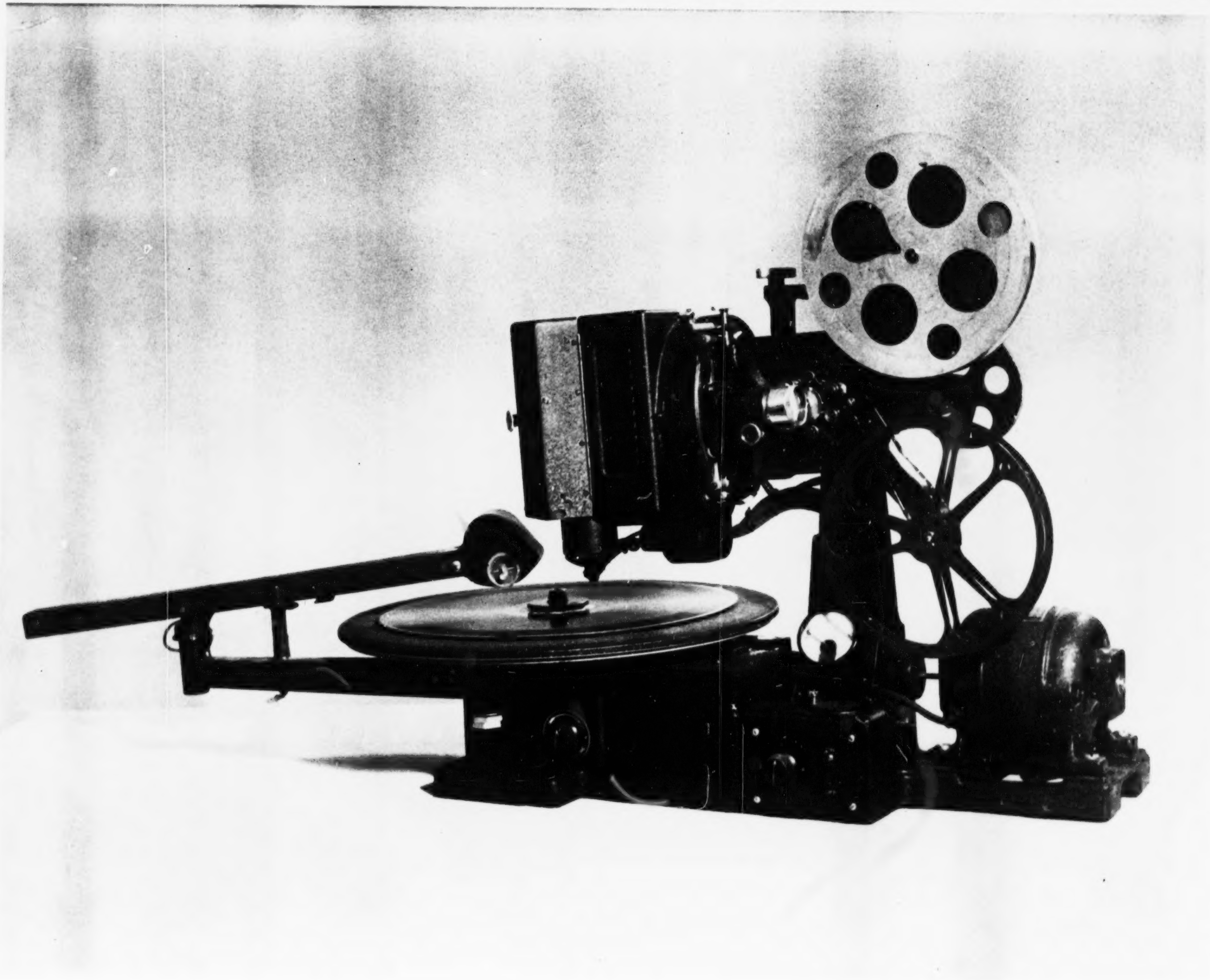
EASTMAN KODASCOPE Model C. showing reels in place. NOTE that the reels themselves are of much later vintage. The cover has been removed to show the mechanism. x



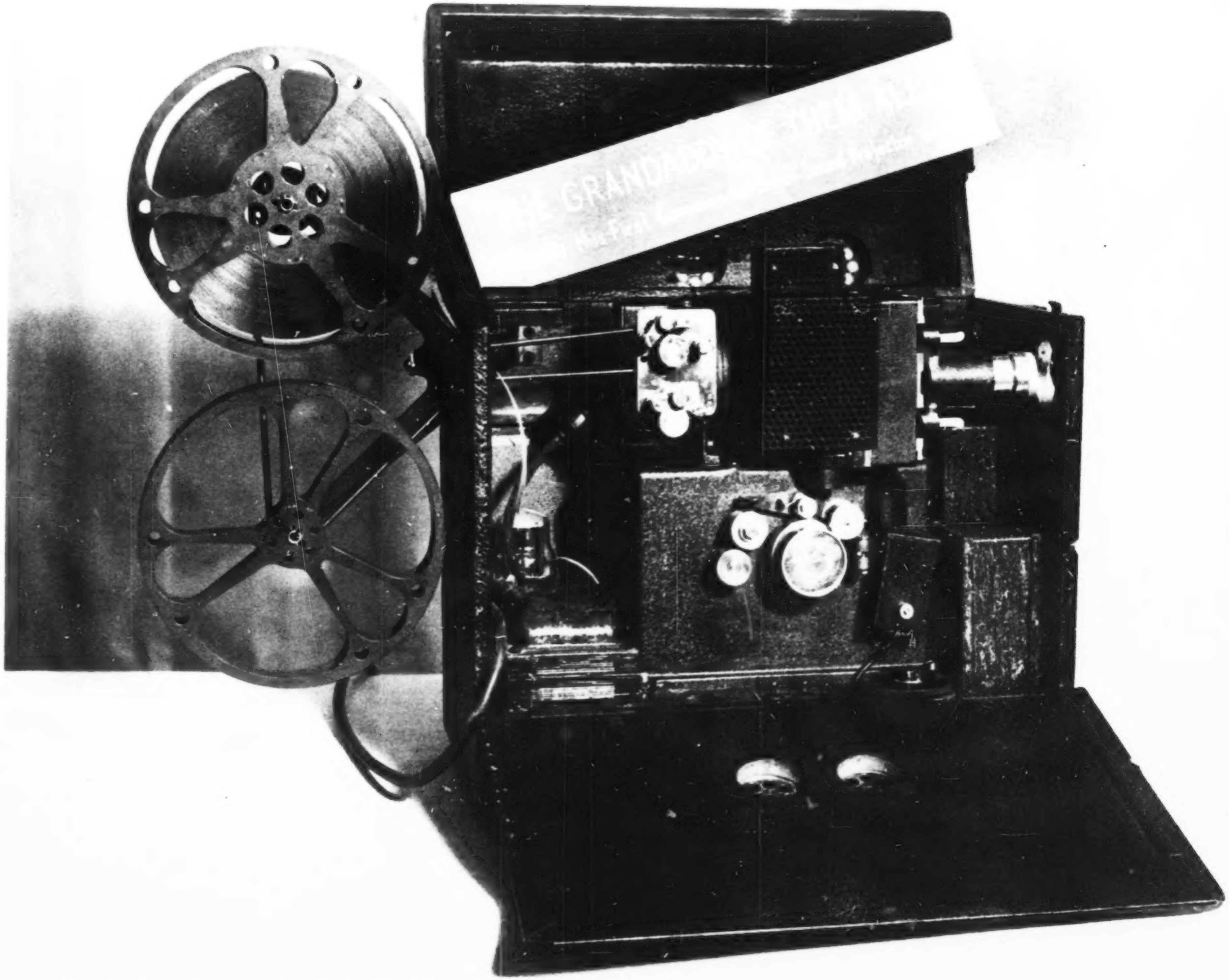
EDISON PHONOGRAPH . Sound was engraved on wax cylinder with a stylus, and then played back with another. Hand cranked spring motor drive.


BK-401 SOUND MIRROR by Brush
"Magnetic Ribbon"
First Tape Recorder in U.S.
March 1946 IRE SHOW New York City

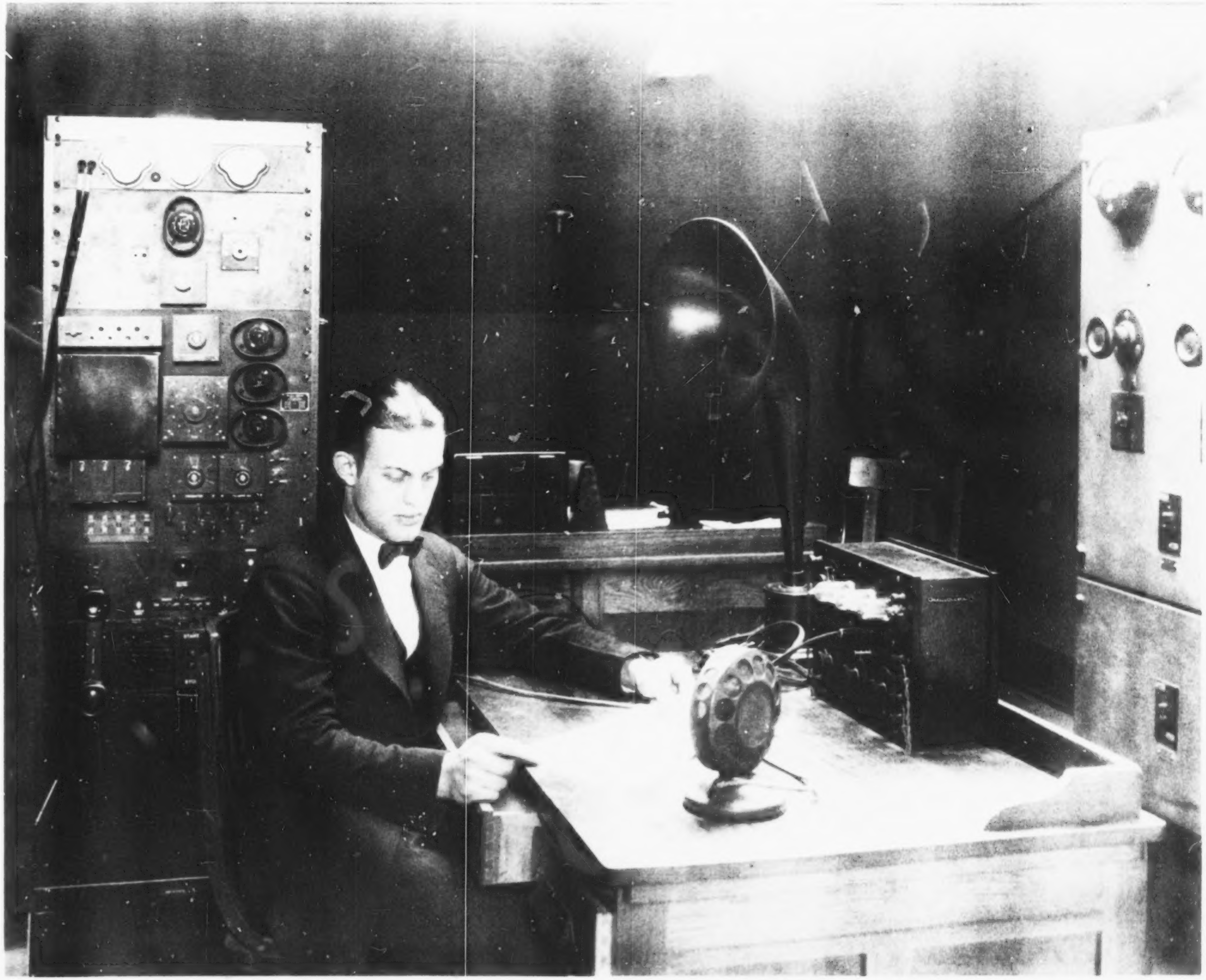
BRUSH "Sound Mirror" first paper, then acetate, tape recorder in the U. S. Shown at International Radio Exposition, New York, 1946.



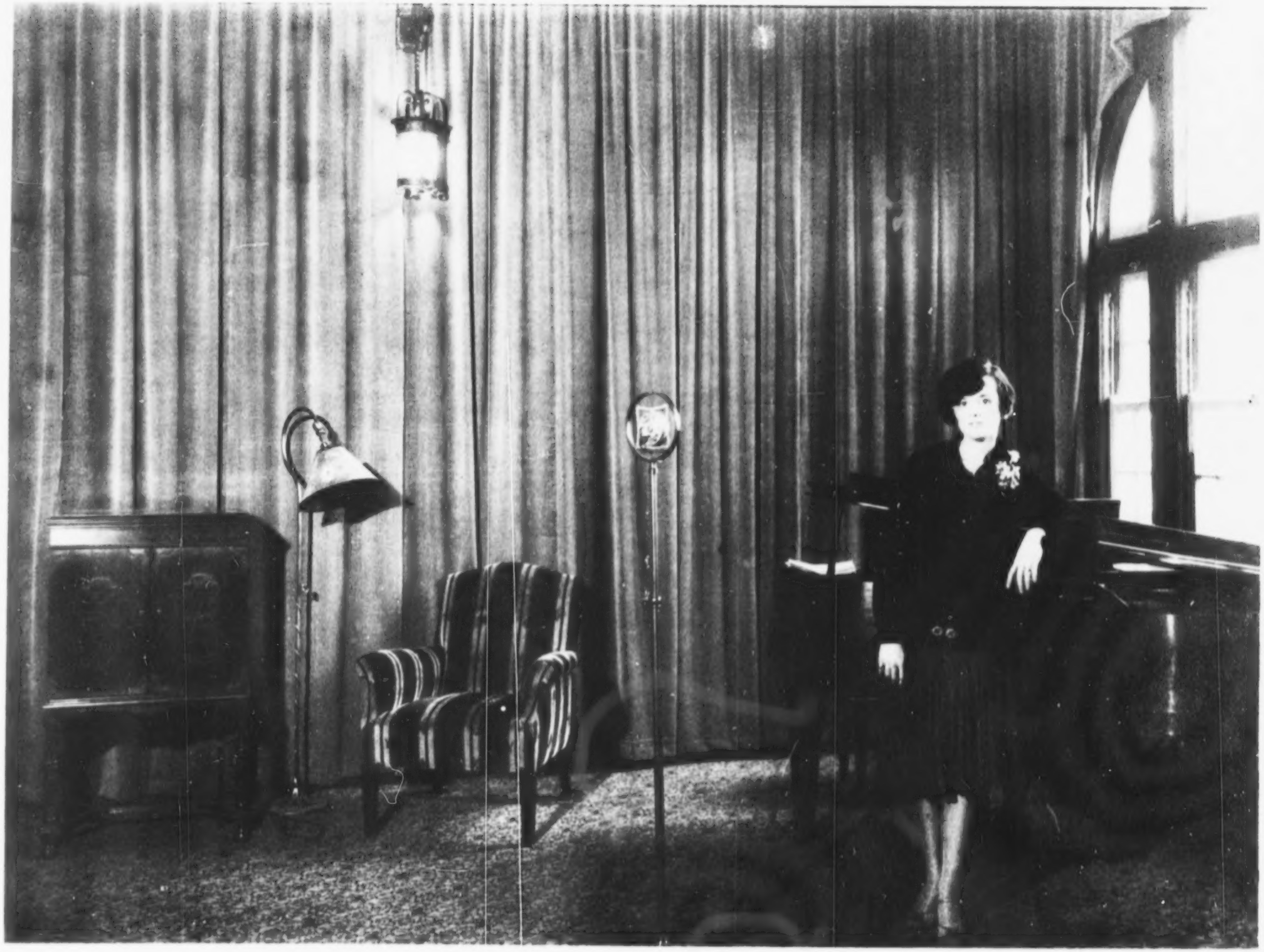
VICTOR ANIMATOPHONE - 16 mm sound-on-disc projector, 1930 (?), made for Electrical Research Products (ERPI), subsidiary of Western Electric Company, prior to development of 16 mm sound-on-film.



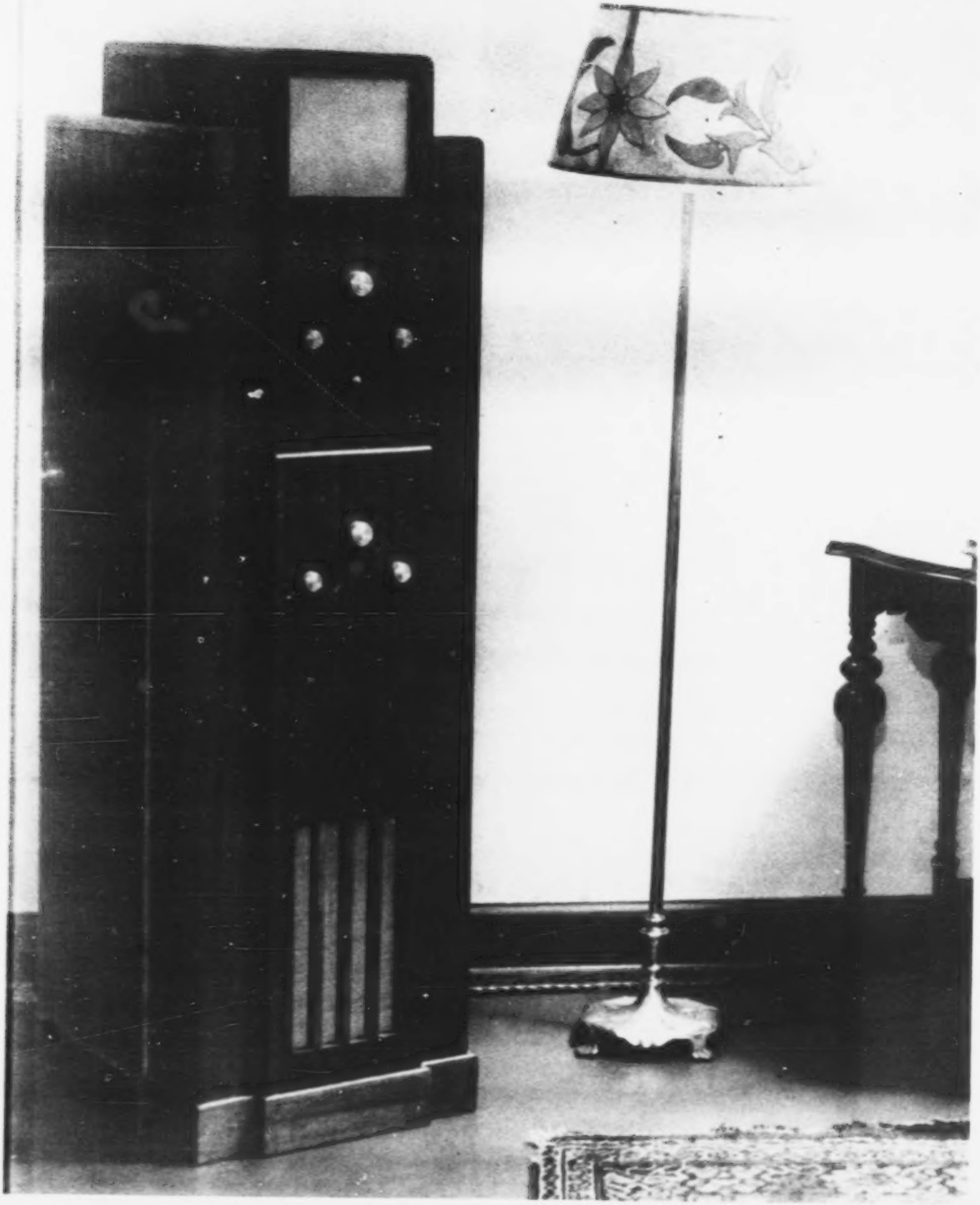
RCA 16mm sound-on-film projector first shown at NEA Superintendence meeting, Atlantic City, 1931. It had only a 50-watt automobile type lamp, and was ostensibly intended only for home showings, the school and other non-theatrical fields having been allocated by agreement to Western Electric, which was pushing 35 mm theatre-type service contracts for schools.



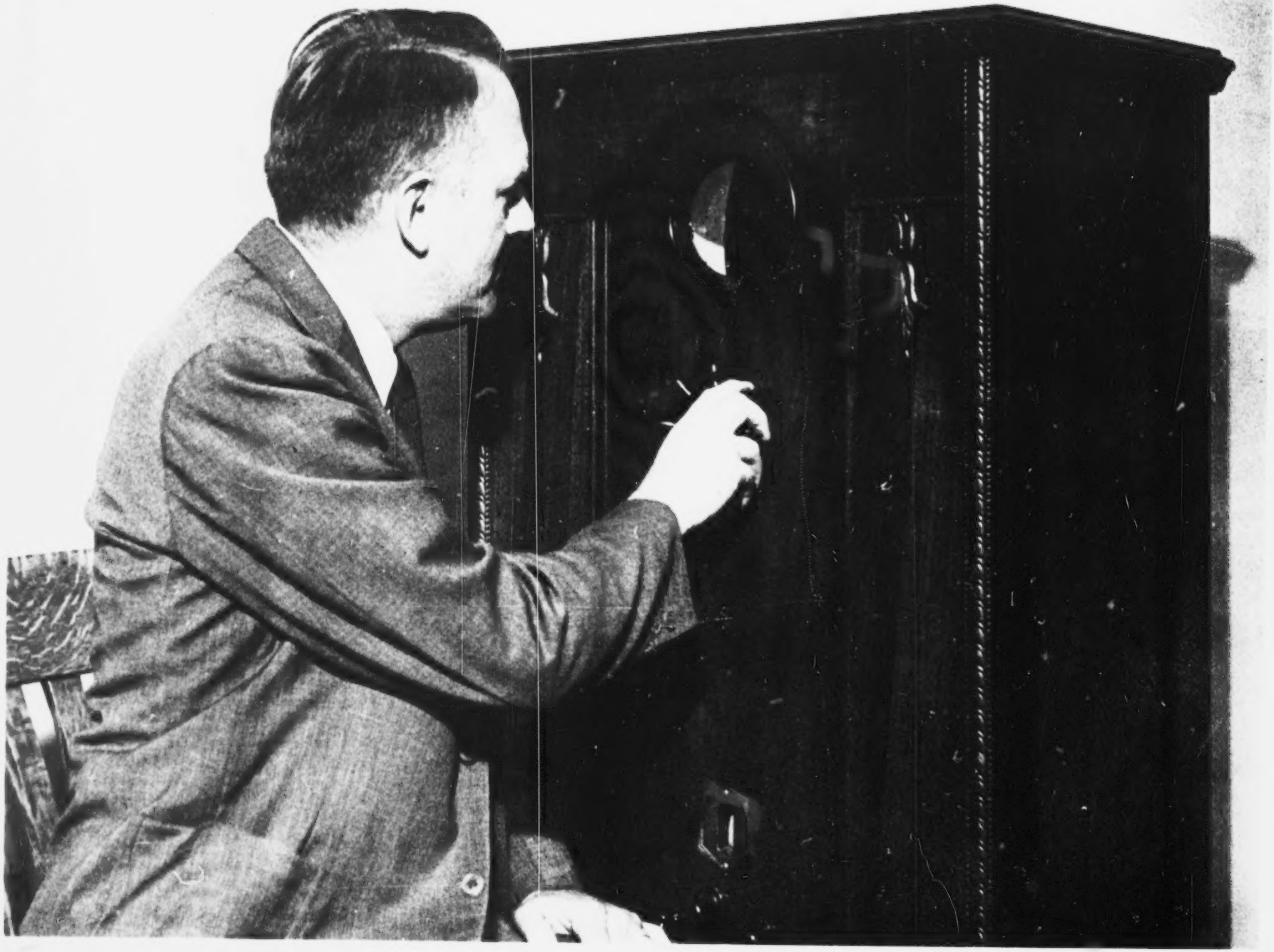
Carl Menzer, Director, Radio Station WHAA (later changed to WSUI) of the State University of Iowa, shown in a combination broadcasting and control room, March 1924.



Studio WHAA (later WSUI), State University of Iowa, March 1924.



Receiver developed for educational television by the State University of Iowa about 1932.



Professor E. Kurtz, State University of Iowa, experimenting with a receiver for educational television about 1932.